THE UNIVERSITY OF CHICAGO

AN EXPERIMENTAL STUDY OF TRANSFER OF RESPONSE IN WHITE RATS

A DISSERTATION

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SECTION ONE

INTRODUCTION

The experiments reported in this paper were inspired by the conviction that almost all of the work previously done on the problem of the transfer of response or the transfer of learning lacked exact definition and control of the factors involved. But in spite of this lack two generally accepted conclusions have been fairly well established: (1) Transfer, *negative* as well as *positive*, in varying degrees has been found; (2) A satisfactory theory of explanation must find its basis in the " something in common " or the " identical elements " in the problems or situations between which the transfer occurs. However, to get at the actual conditions under which transfer, both positive and negative, takes place, and to state the explanatory principle in a definite and usable way, it is necessary *to define the two problems between which transference is tested accurately and completely in terms of each other as to their similarities and differences.* One can then find by concomitant variation what factors and conditions are correlated with positive and negative transfer and the relative influence of these factors and conditions upon one another. This, of course, has been attempted. One needs but to glance at Coover's(1) whole page of " identical elements " to be convinced of this. But to facilitate this analysis two conditions are favorable: (1) Simplicity of problems. This, too, has been attempted. It is the keynote of most attacks on the problem. Instead of trying the effect of a certain course of study upon practical success in some chosen business or profession, the experimentation has taken up simple cases of memory, discrimination, etc. But these are not sufficiently simple. One element of complexity is the central or subjective factors involved in what goes under the names " attention," " general ideas," " ideals," etc. Hence comes our second condition suited to facili-

tate analysis,—i. e. (2) the reduction of the problem to perceptible and definitely measurable objective terms—*sensory* stimulus and *motor* response. This condition has not been obtained and can not easily be obtained with human subjects. It can presumably be best obtained with animals. Without attempting any exhaustive survey of cases, let us notice briefly the problem as studied in animal psychology.

It is well to bear in mind at this point that whatever study has been given this problem up to the present time by those experimenting with animals has been largely of an incidental character. Yet the incidental results have often been interesting and suggestive.

The problem has presented itself to most of the animal psychologists in this form: What is the effect of previous habits upon the formation of new habits? Yerkes(2) study of the Dancing Mouse has furnished some data bearing on the question as stated. Animals which had not been previously trained on a simple labyrinth (C) succeeded in making the trip correctly for the first time on the average after 19.7 trials. Animals which had previously learned the labyrinth (B) succeeded in making the first correct trip in (C) after 7 trials. The learning of (B) without previous training required 8.2 trials. After previous training on (C), the learning of (B) required 5 trials. Thorndike(3) reports in his experiments with cats in problem boxes, that " previous experience makes a difference in the quickness with which the cat forms the associations. After getting out of six or eight boxes by different sorts of acts the cat's general tendency to claw at loose objects within the box is strengthened and its tendency to squeeze through holes and bite bars is weakened; accordingly it will learn associations along the general line of the old more quickly." He cites three animals, Nos. 10, 11, 12, which had learned the problem box A (0 at front) and were afterwards taught the problem box B1 (0 at back). He remarks, " It naturally takes a cat much longer time to accidentally claw a loop in the back than in the front, yet a comparison of these curves with those—shows the opposite to have been the case with 10, 11 and 12." A parallel series of controls

is needed here, however, to make sure the statement. Richardson's(4) experiments on white rats also furnish some data. Two sets of rats were obliged to learn to respond correctly to box III. One set had previously learned to respond correctly to boxes I and II. The curves for the two sets show a decided advantage for the trained rats. Yoakum's(5) experiments with squirrels show that training is sometimes a disadvantage. Thus animals trained on box I and box II took a longer time to learn to open box III than animals which had had no training with boxes I and II. The responses required in the first two boxes, such as scraping, butting up the latch with the nose, were carried over to box III where a different response was required. Hunter(6) offers two sets of experiments bearing on this question, only one of which will be mentioned here, the other being discussed later. In his work on pigeons he found that there was no difference as to number of trials required for trained and untrained animals in learning a given maze where training had been on another maze. The excess time and errors during early trials were greater for the trained, yet the excess effort was eliminated in a smaller number of trials by the trained.

Bogardus and Henke(7) also made some tests upon the question of transfer in the case of rats learning a maze. The animals were taught a certain maze. Then by use of doors for blocking the true pathway at certain points and for opening up the pathway at new points, the correct pathway was altered in certain respects. Then the animals were taught to run the new pathway. An effort was made to make the maze different, each time any alteration was made, in but one respect. These were arranged according to what was judged to be their relative difficulty in order I, II, IV, III, V, number I being the original maze. The actual order of difficulty in learning these five proved to be, as shown by the table of results, V, IV, III, I, II. This leads to the conclusion that the disadvantages of the old habits rather overshadow their advantages, that is, that responses to the previously learned maze were carried over to the new maze and actually proved a hindrance to the formation of the new habit. In Watson's

work on Animal Education where animals were taken from one problem to another, the results were generally found to be advantageous.

Whatever advantage, however, is shown by previous training in any of these cases can be explained in part at least by saying that the animal carries over the food seeking reaction, that fear and emotional disturbances have been eliminated, and that a definite manner of attacking the problem has carried over. In so far as these factors enter into the new problem positive transfer was shown. Likewise where the responses have some similarities postive effects obtain. But we also find negative effects in varying degrees. In Bogardus' work the negative overbalanced the positive effects. In his work the responses were similar in some respects and different in others. It was attempted however, to make the maze different in but one respect each time a change was made. But upon examination we discover perhaps three important changes which entered in each time: (1) a change in the direction or amount of turning at the critical point, (2) a change in the length of the runway at the critical point, (3) a change in the order of succession of the runways of different lengths at the critical point. Of these perhaps the first would be most important, although the third has been shown by Watson to be very important also. In fact the maze reaction has never been carefully enough analyzed to be used successfully in transfer tests. At least it is too complex to serve for pioneer tests. So our conclusion must be that in none of the experiments mentioned has there been a careful analysis of situation and response into their various factors and then a careful control and variation of those factors. Both situation and response have been varied in a lump or grossly. This is just the criticism that has been offered on a previous page upon the experiments on the same problem in human psychology.

Thus while the taking over of the problem from the human field into the animal field has secured simplicity in as large a measure as seems possible by the elimination of the central or subjective factors, yet there is still too

much complexity of objective factors and a lack of accurate analysis and definition of the relation of the two problems in terms of similarities and differences.

It seems to the writer, therefore, that if the experiments upon this problem are to have any finality and secure for us the solution of the problem they will have to begin with such conditions as will either keep the response as a whole constant and vary the stimulus or situation one factor at a time, or keep the stimulus or situation as a whole constant and vary the response one factor at a time. From some such simple beginning we could then pass, as experience and technique indicate, to tests where more than one factor of the stimulus or situation was varied while the response remained constant, or to tests where more than one factor of the response was varied while the stimulus or situation remained constant, or to tests where one or more factors in the stimulus or situation and one or more factors in the response were varied while all others in the *stimulus* and in the *response* remained constant. Most experiments which have been performed would presumably fall under the fourth class mentioned, although no careful analysis, especially of the response side, has been made in any of them, and in many no careful analysis of the stimulus or situation. We have already cited Bogardus and Henke's tests. For further example, how much, and what change is made in the stimulus and how much and what change is required in the response in passing from one of the boxes used by Yoakum to another, or from one of Hunter's mazes to another? Shall we, following Thorndike's principle of identical elements, decide upon the amount of likeness or difference of the two problems by the amount of transfer shown when one is learned after the others? The true course would require first such an analysis and control of factors as is suggested above and a long series of experiments in which control was present, in order to furnish the only sound basis for Thorndike's principle, or any other.

It appears to the writer, moreover, that after all, the problem back of the transfer of learning finds one of the best points of attack, as suggested above, in the form in

which the response remains constant while the stimulus is varied under proper control. Evidently such a situation is in mind when the problem of transfer is spoken of as the problem of general training, of generalized response, of generalized habit. Is there such a thing as generalized response? Will a response which has been learned for one stimulus or situation be found to carry over in any degree for a stimulus or situation which is different in a definite way from the first stimulus or situation? If so, under what conditions does such a transfer take place? The experiments reported in this paper were designed to answer partially these questions. How successfully they have done so will appear in the issue. They represent an attempt to secure both the greatest simplicity possible and an accurate definition of the relation of the two problems. Both have the same motor response, both present the same sensory situation except in one definite particular and both presumably have a minimum of central factors. Before presenting the writer's experiments, however, let us notice a few theoretical considerations and some further experiments that bear upon the question in the form in which this paper expects to deal with it.

Theoretically it is possible for a " generalized response " to occur under two widely different conditions: (1) under circumstances in which discrimination of the stimuli is not possible for the organism called upon to make the response, or if possible, has not yet been learned; (2) under circumstances where discrimination of the stimuli is possible and is known to be made by the organism. Thus under number one would fall such cases as those where an animal makes the same response to all colors owing to an apparent inability to discriminate differences in colors, making the response wholly on the basis of brightness. Also the case of the child calling all men " papa " might be mentioned. These are to be looked upon not as cases of " transfer of response " or " generalized response " between previously discriminated particulars, but as cases merely of the absence of discriminated particulars. They represent a primitive and unspecialized stage, not an advanced state. Under number two would fall what psy-

chologists are pleased to call, in their advanced stage in human psychology, " concepts," " generalizations," and " abstractions." Psychologists have not hesitated to apply the term " generalized response " to what is included, on the behavior side, under the terms mentioned. Thus to quote Angell(8): " Concepts of adults may also be considered as forms of generalized motor activity." Gore(9) sets forth something of the same idea. The idea presented is that the essence of such types of behavior after all lies in the fact that one response serves for a multitude of stimuli, situations, objects. The word " man," for instance, serves as a proper and efficient response to a whole group of objects and to each member of that group. The question before us in this paper is, when looked at from this point of view, whether we can get experimental data bearing upon this second type of " generalized response " or " transfer." Can we actually get well controlled situations where a response learned for one stimulus is transferred to another different stimulus? If so, what are the conditions of such transfer?

We find simple experimental illustrations in human psychology in the reaction experiments. Here one learns to make a simple response, pressing a key, upon the reception of a certain stimulus, say a visual stimulus. The same response is required upon the reception of a second stimulus of a different kind, say an auditory stimulus. So likewise with a touch stimulus. While such experiments furnish us little data on the conditions of transfer, yet they do suggest methods of procedure. In animal work we find also suggestive data. In Hunter's work(10) on the auditory sensitivity of the white rat he reports that his animals reacted properly (a given, required, controlled response in all cases the same) when either of the following noises were substituted for the standard whistle: the rush of air through the whistle; sound of the rush of air made with lips, and clapping hands. He found also that animals trained to react to hand clapping reacted successfully to the following noises when these were substituted: rattling of paper, dropping sunflower seed on tin, scratching on wood, drumming on table with fingers, etc. Here it may be contended

that the response is a " generalized " one, but one belonging to the first type mentioned above. We have no definite ground for believing that the stimuli mentioned—all belonging to the group called noises—were in any way actually different stimuli for the animals tested, so we can not maintain that this furnishes an illustration of transfer between " different " stimuli, the second type mentioned above.

Better illustrations, perhaps, can be found among cases which are said to illustrate " substitution." Here one feature of the situation being the dominant one in arousing the response to the situation comes to be replaced by another as the dominant element. Watson(11) in his book on Behavior defines substitution as follows: " By substitution we mean that a stimulus which originally did not call out a given response comes later to call it out." He cites two examples. One is from the Pawlow type of experiment on dogs, in which a green light came to call out the salivary secretion in large amounts when the sight of the food had been the dominant stimulus for that reaction. The other is the experiment with cats which Thorndike(12) offered as a tentative proof of the presence of ideas in animals. Here the clapping of hands came to be the dominant stimulus in calling out the desired reaction, although the laying of fish on the top of the cage had been the dominant stimulus. Further examples might be taken from experiments with rats learning the maze. In the work of Bogardus and Henke(13) it was shown that rats make considerable use of tactual stimuli in learning the maze, although when once thoroughly learned the response was largely in kinaesthetic and organic terms, as Watson contended. It is evident then that here we have a substitution of kinaesthetic and organic stimuli for tactual as dominant in securing the required response. In the later work of Vincent(14) we have admirable illustrations of the same sort of thing. She has showed that the maze is probably learned in tactual, visual, and olfactory terms, when the maze is so constructed as to call these into play. Later the kinaesthetic and organic come to be substituted for them. Yet the kinaesthetic never becomes accurate enough to maintain correctness but needs almost constantly some sort of cutaneous guidance.

Cases of " substitution " are, in the opinion of the writer, after all cases of " transfer " of a certain sort. The essential characteristics of one type of transfer are all present, i. e., a certain definite, required response which is kept constant and a definite variation in the nature of the stimuli or situation calling out the response. While it can not be maintained that in the maze problem certain stimuli were removed and others, which had not been present before, put in their place, yet there is evidence that as far as effectiveness of the stimuli goes, such was actually the case. In the experiments to be reported in this paper the conditions were so made that one stimulus which was shown to be the dominant one was actually removed and another, which had not been present before, was substituted for it so that it became the dominant one in place of the former. These dominant stimuli were taken from the different sense fields, light, sound, and pain, so that a stimulus from one sense field was replaced by a stimulus from a different sense field. In this way it was hoped to secure results which were based on stimuli which were simple, but which were also as different as it was possible to secure. Of course these dominant stimuli had for their background or setting the entire situation composed of various stimuli from the box, room, etc. All these were conditioning stimuli, it is true, but not the dominant ones. All these conditioning stimuli were kept constant, the dominant stimuli alone being changed. The response also was kept the same. By such a method we hoped to secure some reliable and important results bearing on the possibility of one and the same response serving for two or more different sorts of stimuli, or on the possibility of a " generalized " response of the second type mentioned above.

SECTION TWO

GENERAL FEATURES OF THE EXPERIMENTS

A. *Animals Used.*

The animals were white rats of the same species as used by Watson, Carr, Vincent, and others in work done in the same laboratory in previous years. The rats were for the most part young animals, beginning the work when some three or four months old on the average. When young animals were not used the fact will be found indicated in the detailed reports of the experiments. In all, close to one hundred and seventy-five animals were used. They were divided into groups of five or six or seven to the group, and the record for such a group was taken as representing what the normal animal would do on the average under like conditions. The food used was sunflower seeds. This allowed better control of amount secured at each trial than other types of food at hand.

B. *The Two Types—Positive and Negative*

Two series of experiments were planned and carried out. In the first series the attempt was made to teach the animals a definite *positive* response to one sort of sense stimulus. Then a second sort of stimulus was substituted for the first. The purpose was to see whether and to what extent such a response would carry over from the first to the second. This series falls into two groups: (a) where the response was first learned to the light stimulus, and then the sound stimulus was substituted for the light; (b) where the response was first learned to the sound stimulus, and the light stimulus substituted for the sound.

In the second series a negative response was required in all cases. The purpose was the same as in the positive series. This series falls into six groups: (a) where the response was first learned to the light and the sound substituted, (b) where the response was first learned to the

light and the electric shock substituted, (c) where the response was first learned to the sound and the light substituted, (d) where the response was first learned to the sound and the electric shock substituted, (e) where the response was first learned to the electric shock and the light substituted, (f) where the response was first learned to the electric shock and the sound substituted.

C. *Positive*

(1) Apparatus.—The apparatus consisted of a wooden box whose plan is shown in figure I. The base LMNO upon which the box rested was approximately two feet by three. The food box (F) was 13 inches wide and 13 inches long on one side but longer on the other because of the entrance of the two return alleys as shown in the figure. ED is a door which leads from the food box to the main part of the box (B) through the entrance alley (EA). This entrance alley was four inches in length. X and X′ are the entrances to the return alleys (RA and R′A′). RD and R′D′ are doors from return alleys to foodbox.

S and S′ are sounders hung just outside of the box close to three-quarter inch holes through the side of the box into the heads of the return alleys. Lt and Lt′ are two small electric light bulbs just inside the wall of the box and just above the holes mentioned above. K and K′ are two keys which control the left and right sounders and the left and right lights respectively. Sw and Sw′ are two switches which allow the use of the same keys (K and K′) for both the sounders and the lights, either singly or simultaneously. Thus the key (K) could be used to work the sounder (S) or the light(Lt) or both the sounder (S) and the light (Lt) simultaneously. The sounders were small electric buzzers so fixed that with one pressure of the key but one click was produced, instead of the rapid succession of clicks ordinarily produced by such an instrument. The lights were small electric bulbs of approximately one and one half candle power. The current necessary was produced by a cell of dry batteries indicated in the figure by the letters DB. The box and all partitions were six inches deep. The alleys were five inches wide. All the alleys were

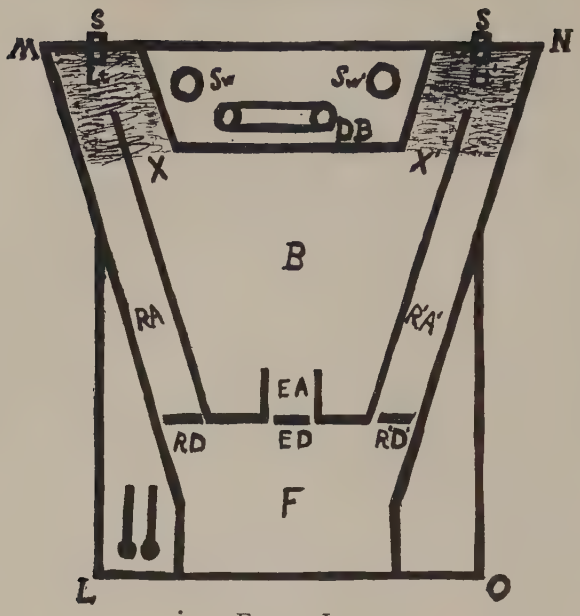

FIGURE I

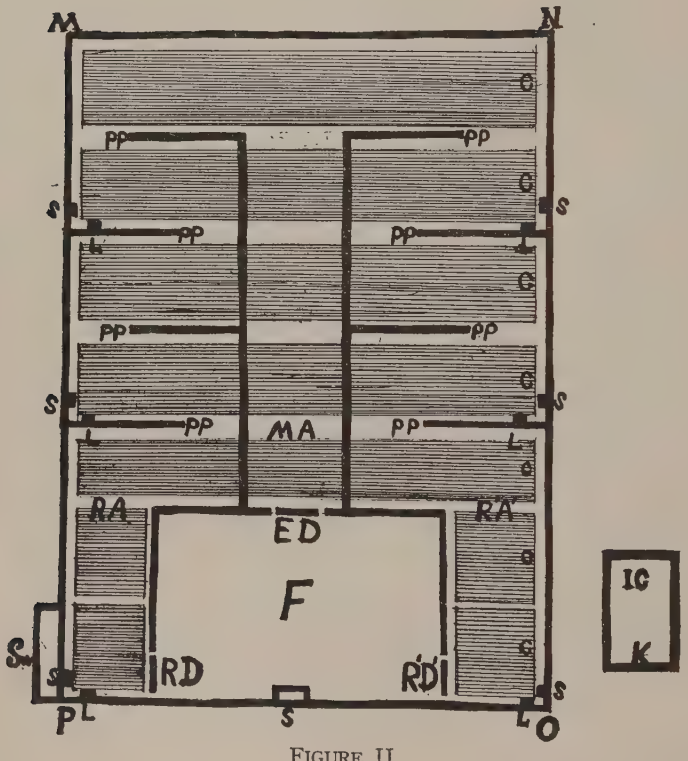

FIGURE II

uncovered excepting the heads of the alleys where the sound and light stimuli were presented. The covered portions are indicated in the figure by shading.

(2) Method of Procedure,—The animals were first tamed by being fed in the experiment boxes, by being handled freely by the experimenters, and by being allowed free run of the box until all emotional factors were removed as far as possible. The regular day's work for any animal was a series of twenty trials. However, when just beginning to learn, the animal was given fewer trials and gradually brought up to the full stint.

The standard adopted in this series as indicating that the animal had learned the problem was 95 correct responses out of 100 chances. Since a daily series consisted of 20 trials, the standard required the completion of five successive series of 20 trials each with not more than one error on the average to each series of 20 trials.

Normal records were secured first for the sake of comparision. These served to indicate how many trials and series of trials were necessary for the average untrained rat to learn the response to each of the various sorts of stimuli used in the experiments. Then rats which had learned to respond to one stimulus, say light, for example, were required to learn the same response to another, sound, for example. Then this 'sound' record was compared with the normal 'sound' record to see whether there was any advantage or disadvantage in first learning the response to the light stimulus. Also, in some cases, after the response to one stimulus had been learned, this stimulus was presented simultaneously with another sort to determine the effect of simultaneity of presentation upon the learning of the response to the second sort.

In regard to 'controls,' the simple expedient was adopted of omitting the stimulus and observing the effect upon the behavior. The series of 20 trials in which the stimulus had been omitted was compared with the series in which the stimulus had been presented, and the effect of the presence of the stimulus inferred from the comparision.

Two sorts of stimuli were used in the positive series — light and sound. The particular method of procedure with

any one animal was to place it in the food box (F), allow it to secure a morsel of food, open the door (ED) into the alley (EA), then press the key K or K′, as the case demanded, and thus require the animal to choose the lighted or the noisy return alley. In case the animal entered partly or wholly into the unlighted or the quiet return alley it was accounted an error. The door from the unlighted or the quiet return alley to the food box was kept closed. The light stimulus was not always given as a continuous stimulus in any one trial until the choice of correct return alley had been made. The stimulus was given sometimes continuously and sometimes brokenly. Care was taken that the action of the key (K or K′) was noiseless. In case of the sound stimulus it was at first attempted to sound the clicks regularly until the correct choice had been made. This plan, however, was not followed in all the work reported. Whenever a different course was followed it will be indicated. The following order of choices between right and left return alleys was required in each series of 20 trials: L, R, L, R, L, L, R, R, L, R, L, R, L, L, R, R, L, L, R, R.

D. *Negative*

(1) Apparatus,— The apparatus for the negative response consisted of a box approximately two feet by three, MNOP in figure II. F represents the food box approximately 12 inches by 14 inches. This food box had three openings or doors, ED being the entrance door from food box into main alley, MA; RD and R′D′ being return doors from return alleys, RA and R′A′, to food box. All the alleys had a uniform width of approximately five inches and a uniform depth of six inches. From the main alley, MA, two winding alleys led back to the food box. These are marked RA and R′A′ in the figure and are spoken of as return alleys. PP are partial partitions obstructing the view of the return doors and causing the animal to take a devious course back to the food box. C, C, C, etc., are brass plates practically covering the entire width of the bottom of the alleys and are joined to batteries and an induction coil, IC in figure. S, S, S, etc., are small electric sounders of the same type as used in the positive experiments. They are here hung just inside the

walls of the box close to the partial partitions, excepting the one found on the wall of the food box. These sounders are also joined to the batteries. L, L, etc., are small electric lights of the same size as used in the positive experiments. They are attached to the partial partitions near the sounders and are also joined to the batteries. In one box used for these experiments a switch was attached to the side of the box, marked Sw in the figure. This switch was used to turn the current into the right or left sounders or lights as the case demanded. A later box had a slightly different arrangement. Two keys were used on the battery and induction box, one for the right and one for the left. This allowed of more rapid and less noticeable action on the part of the experimenter when giving the stimulus or combination of stimuli required in any particular case. The sounders, lights, and brass plates were so wired as to allow them to be used singly or in combination. Thus the lights on any one side could be used alone or in combination with the sounders of that side or in combination with the brass plates for pain stimuli. Also it was arranged at first so that one, two or all three of the sounders might be used at any one time. This was found to be unnecessary, however, and so it was finally arranged that all of the sounders on any one side would come into play by pressing the key controlling the sounders on that side. The sounder found on the wall of the food box was the first one used in attempting to teach the negative response to the sound, but it was found necessary to place the sounders along the side of the box as indicated above before the animals would pay sufficient attention to them to learn the response required in any reasonable number of trials. So the sounder in the food box was abandoned and the sounders along the side were substituted. Since the wiring required was rather intricate no detailed description of it will be given here. Any electrician can make the proper connections to secure the working combinations of sound, light and pain required in the experiments.

(2) Method of Procedure, — The animal was put through the entrance door (ED) into the main alley (MA) and was required to go up the main alley and back to the food box through either the right or the left return alley (RA or R′A′).

When the animal had entered either of these return alleys the stimulus was given, that is, the light or sound or electric shock, or a combination of any two of them as the case might require, and the animal was required to go back and come down the other return alley to the food box. In fifteen out of every series of twenty trials the proper stimulus was given and the animal was required to turn back and enter the food box by the other alley. In the other five trials the animal was allowed to continue on its chosen way and return to the food box, no stimulus of any kind having been given. These five where no stimulus was given were scattered irregularly through the series of 20 to prevent any possibility of the animal's learning a definite fixed order in the series. The purpose was to train the animal to stop at a given stimulus, to turn around, and to go back to the food box through the other return alley but, when given no stimulus, to proceed on to the food box through the alley first chosen. When the animal was first learning, the stimulus was given more or less irregularly as to loudness and continuity from the time the animal had fully entered the return alley until it had turned back, even if the animal persisted in its course until it found the door at the end of that alley closed. The fact is that the usual course was for the animal at first to ignore completely the stimulus other than a short delay for examination and to proceed clear down to the closed door at the end of the alley. After the first strangeness had worn itself away, which happened after a few trials, there was little indication, if any, to show that the stimulus was sensed at all until actual learning of the required reponse began. However, as accurate records as possible were kept of hesitations as well as of the actual times of turning back, when the hesitations were apparently due to the effect of the stimulus. Sometimes also in the learning process the speed of the reaction was apparently much lessened by the disturbing effect of the stimulus. This was particularly true when the light stimulus was used, so a record of these was also kept. Both doors, RD and R′D′, were kept closed until a choice had been made, when the proper one was opened as noiselessly as possible. An attempt was made to prevent the experimenter's movements from being so evident, as to become cues for the

animal. A response was counted correct provided the animal had fully entered one or the other of the return alleys and turned back, when the stimulus was given, before it had reached a point where there was any possibility of its seeing the closed doors of the alley. After the animal had begun to learn it was given the stimulus when at various places to prevent the formation of position habits. Thus sometimes the stimulus was given just when the animal had entered the alley, sometimes when it was half way down the alley, and sometimes when it had come almost to the point where the closed doors could be seen. By such a variation the animal would not learn to stop at any particular place but only when the stimulus was given. The omission of the stimulus five times out of twenty trials also prevented the formation of the turning habit regardless of the presentation of stimulus and served as an effectual control. The standard adopted for the negative series was 100 correct responses out of 105 chances to respond to the stimulus given. Since the stimulus was given but 15 times out of each series of 20 trials it required the completion of seven such series with but five errors all told to meet the standard.

SECTION THREE

FEATURES BEARING ON LEARNING

A. *Positive*

(1) Light—Two groups, I and II, were trained with the light stimulus and were then transferred to the sound. The following tables give the results as to the number of trials and series of trials necessary for learning the light sufficiently well to meet the standard of 95 correct choices out of 100 chances.

GROUP I

Animal	Trials	Series
No. 15.....	680	34
No. 16.....	880	44
No. 22.....	640	32
No. 23.....	460	23
No. 26.....	340	17
Average.....	600	30

GROUP II

Animal	Trials	Series
No. 17.....	920	46
No. 18.....	580	29
No. 19.....	580	29
No. 20.....	600	30
No. 21.....	540	27
No. 25.....	560	28
Average.....	630	31.5

Average for 11 animals, 616.36 trials, 30.81 series.

This average for eleven animals can be taken as a normal record for learning a positive reaction to a light stimulus under the conditions of the experiment.

It will be noticed there is great variation in the number of series and trials required for the individual animals to learn the response. Thus number 26 needed only 17 series or 340 trials, while number 17 took 46 series or 920 trials. For this reason group curves would not show the characteristics of the learning process. So two typical individual

curves have been given instead. The curves for number 22 of Group One, (Figure III) and for number 25 of Group Two (Figure IV) are given. These curves show not only the learning of the response to the light stimulus but they also indicate the record for the control series in each case.

These curves indicate neither a rapid initial rise nor a long period of final perfecting of response. They rather show a gradual, though very irregular, rise from the beginning to the end of the learning process.

The unusually large number of trials required by Numbers 16 and 17, for learning the light finds its explanation, apparently, largely in terms of distracting olfactory stimuli. The males in these two groups were kept in a cage by themselves and were given their daily stint of work immediately after the females of the two groups. The two individuals mentioned, being unusually vigorous animals, were constantly attracted apparently by the odors left by the females and would often wander about the box sniffing here and there to the neglect of the light stimulus. So even after the response had been apparently learned, it took a greater number of series to meet the required standard.

The important thing about learning the light was, of course, to be as sure as possible that the animals were responding to the light and not to other stimuli. The order of presentation of right and left pathways followed in the regular and control series has been given already on page 29. It will easily be seen that position habits might account for a rather large percentage of correct choices in such a series. Of the position habits most likely to be learned the most advantageous would be a double alternation between the right and left pathways. Such a position habit, if acquired, would account for a record in which 80% of the responses were correct. The next most advantageous position habit would be a simple alternation between right and left. That, if acquired, would account for a record in which 70% of the responses were correct. Chance, of course, in any series where two possible choices must be presented an equal number of times, will account, in the long run, for 50% of the responses being correct. A position habit of always going to one side would also give a record in which 50% of

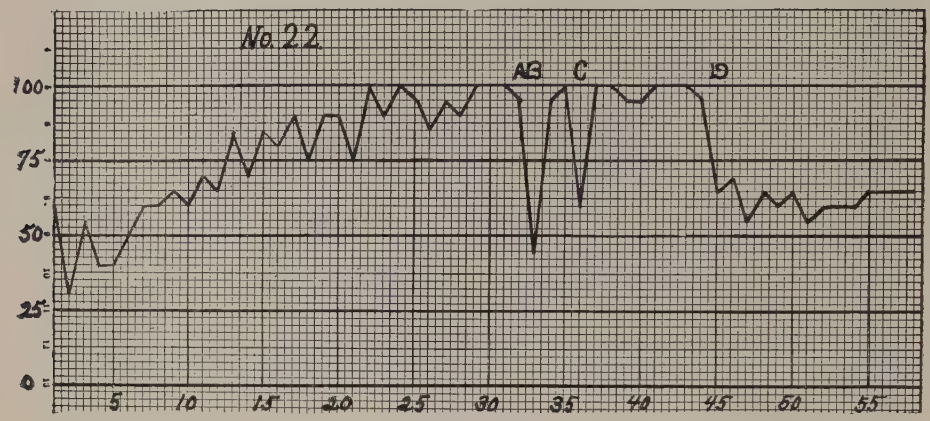

FIGURE III

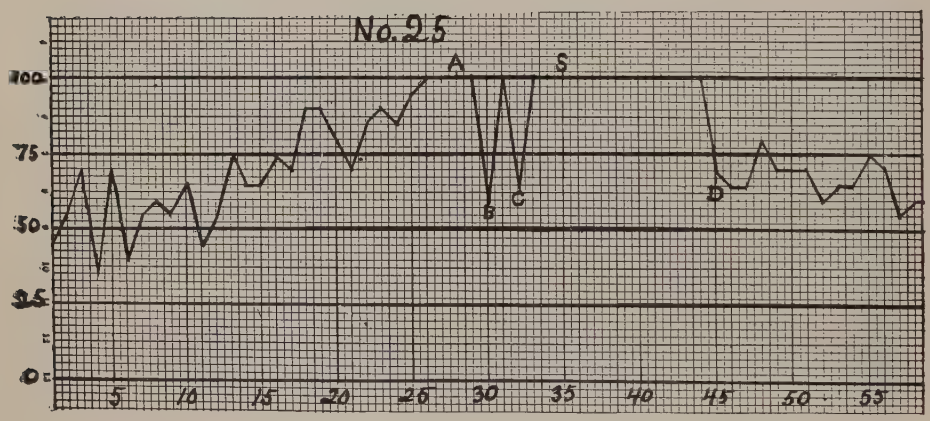

FIGURE IV

Curve 22 (Figure III) is an individual curve from Group One. Curve 25 (Figure IV) is an individual curve from Group Two. The horizontal lines represent the percentage of correct responses. The vertical lines represent the number of series of 20 trials each. In lettering,—A is the end of the learning process with light, B is the first control series, C is the second control series, D is the beginning of training with the sound, S (in Curve 25) is the beginning of simultaneous light and sound.

the responses would be correct. From a study of the daily records it was found that there is no evidence in any case for believing that the animals at any time used the double alternation position habit. A study of the records does show, however, that at first the choice of response was practically a matter of chance. In a very few instances the position habit of always going to one side was picked up after a series or two but was not maintained for longer than one day at a time. Then in most cases there seems to be a gradual shift to the simple alternation position habit, but in none of the cases in this list of eleven animals was such a habit actually learned and consistently maintained *while learning the light. A careful study of the daily records did not reveal a single series where a perfect simple alternation was carried clear through the series while learning the light.* This was not true, however, after the animals had learned the light and had been transferred to the sound. There the animals seemed to be working largely on a basis of simple alternation but not with any degree of consistency. Out of 215 series where sound was given as a stimulus after light had been learned only 20 showed a perfect simple alternation. From a study of the records, however, one must conclude that there is a strong tendency toward using simple alternation in a series of the type used, but that there is little ability to maintain it consistently.

In order to make it as certain as possible that the animals were actually responding to the light stimulus when the required response was considered learned, first, a high standard of excellence was chosen and second, control series were introduced. The standard adopted as indicating that the problem had been mastered was 95 correct choices out of 100 chances or five series in which there was not more than one mistake to a series on the average. The actual fact was that most of the animals met even a higher standard than that, as a glance at the sample individual curves will show. It was not considered probable that the animals used would be able to develop a position habit of sufficient complexity to enable it to respond correctly, 95 times out of 100 even with a series apparently as simple as the one adopted. As indicated above the results justified this assumption. But to be cer-

tain control series were used. After the animal had apparently learned the problem, it was given one or two series without the light stimulus. The result was a drop in efficiency of from 25% to 70% with an average drop of 40%, leaving an average of 60% correct. This is not much above what chance would enable the animal to do. Upon the light being restored again an immediate return to the required efficiency appeared again. This was taken as conclusive evidence that the light stimulus was the dominant stimulus in making the correct response when the percentage of efficiency had reached 95.

(2) Sound—Five groups of animals, III, IV, V, VI, VII, were trained with the sound stimulus preparatory to transferring them to the light. In all 32 animals were trained in these groups. The response required was the same simple positive response required in the case of the experiments with light. Groups III and IV used the sounder mentioned in the description of the apparatus. Group V was trained with the telephone receiver as sounder in place of the regular electric sounder. Groups VI and VII were trained with the telephone receiver as sounder and with pain as punishment for a wrong choice. Groups III and V were older animals than those used in the other groups and had had training on the maze. They were all practically full grown animals.

The results can be summarized very briefly. All the members of group III were given 85 series or 1700 trials without learning the response. All the members of group IV received 60 series or 1200 trials without learning the response. All the members of group V received 40 series or 800 trials without learning the response. Three members of group VI received 40 series or 800 trials, one 35 series or 700 trials, and two 30 series or 600 trials. None learned the response. Four members of group VII received 60 series or 1200 trials, two 55 series or 1100 trials, and none learned the response.

In order to bring to light the significant features of these results we need to notice the method and results more in detail.

In the main, the method with the sound stimulus was the same as with the light. The stimulus was given in a more or less regular way, that is, the sounder was 'clicked' with

more or less regularity until the animal had made a choice. When the choice had been made, whether right or wrong, the stimulus ceased to be given. When the choice was wrong and the animal had returned to the main portion of the box (B in figure I) the stimulus was again given until correct choice was made. However, the animals in groups III, IV, and V, where no punishment for wrong choice was, given, soon learned to work so rapidly that one scarcely had time to give any stimulus, after the animal had been put into the entrance alley (EA in figure I), before a choice had been made. The animal would dash into one or the other of the return alleys (X or X′ in figure I) and, after glancing about the turn at the head of the return alley, dash toward the door into the food box if the choice happened to be correct, or if wrong, whirl quickly and dash into the other return alley and into the food box. When the reaction became of this type, the stimulus was given from the time the animal entered EA until the correct return alley had been entered.

With group V, beginning with the 26th series, the st mulus was given irregularly in place of regularly, that is, the number of times the key was pressed and the sounder 'clicked' varied greatly from one unit of time to another during the time the stimulus was being given. This was done with the idea of attracting the animal's attention. A like change of procedure was made with the animals in groups VI and VII where pain was given as punishment for wrong choice.

Another change of procedure introduced was punishment for wrong choice. The punishment given was an electric shock. The return alleys (RA and R′A′) beginning at X and X′, had small copper plates placed in them and these plates were attached to an induction coil. Two keys were used to connect the circuits, one for RA and one for R′A′. With the introduction of punishment the behavior of the animals was quite different. Considerable hesitation appeared as a rule before choice of return alley was made. This hesitation gave more time to attract the animal's attention by means of the sounder than when the animal rushed pell-mell into one of the return alleys as soon as placed in the entrance alley (EA).

While some improvement appeared, as will be shown

later, yet the main thing to be noticed in the results is that not a single animal out of the 32 trained learned to choose the 'noisy' alley even though some were given as high as 1600 trials and even though pain was used as punishment for wrong choice in the case of a number. Also as will appear later in our study of Transfer effects, even those animals which had learned the positive response to the light failed to learn the same response to the sound. A number of explanations or reasons may be offered for this.

First, it may be claimed that the animals could not hear the sound presented. That is disproved, however, by the fact that other animals did learn the *negative* response to the very same type of sound.

Second, it may be that the reaction required lay outside the animal's ability to learn. However, eleven animals did learn the same response, when a light stimulus was used, with much smaller number of trials than were given with the sound stimulus.

Third, perhaps the rats were negative to the types of sound used and so would not learn a positive response to such sounds. The records, however, do not give any convincing evidence to support this contention. Since the rats had free opportunity to enter either the 'noisy' or the 'quiet' alleys, if they were negative to the sound, we should expect some evidence of it in the early part of the records. The rats should have made many more than 50% of errors until they had become accustomed to the sound. In Group III the averages for the first 200 trials were 46, 49, 51, 53, 50, 51, 48, 54, 49, 56; just about what chance would give in the long run. The records for the other groups show about the same results. No signs appeared in the general behavior of the rats, except in one or two individual cases, that would go to support the contention that they were negative to the sounds presented. Rat number 7 in group III was one of the exceptions. It was, however, an extremely nervous animal and objected to being handled. Its daily record often contains such a statement as the following; " Would not work well today. Seemed frightened." With practically all the animals, however, one could not tell from their general behavior that they even heard the sound at all. As

stated above, the responses became so rapid, where no punishment was given for a wrong choice, that one would be led to think that the sound was wholly ignored. Further, if the rats were negative, the omission of the sounds should show an increase in percentage of correct choices. Let us notice the last 100 trials with the sound stimulus in groups III and IV, and the five control series or 100 trials where the sound was omitted. The last 100 trials with the sound in Group III average 68, 66, 66, 67, 67. The 100 trials without the sound average 69, 69, 69, 64, 64. A slight advantage is shown for those without the sound. In group IV the last 100 trials with sound average 64, 68, 62, 66, 68. The 100 trials without sound average 67, 68, 63, 68, 63. No advantage is shown for either.

Although no convincing evidence can be found in the records that the rats did not learn because they were negative to the sound presented, yet to give the matter a further trial a less metallic sound was sought, if that should prove to be the difficulty in the way of learning. For that reason a telephone receiver was substituted for the electric buzzer used with groups III and IV. A duller, more wooden sound was thus secured. No one of the six rats in Group V gave any evidence of learning the response after 800 trials. Neither the records nor the general behavior showed that the rats were negative to the sound. Groups VI and VII were trained with the same sound as Group V but were given pain as a punishment for wrong choice, but 1200 trials for four of them brought no convincing results.

As a last resort a short test with one rat was tried with a sound to which from general behavior we had every evidence for believing the rats to be positive. This sound was the dropping of sunflower seed in a dish. Any one who has handled rats knows that such a sound will cause in a hungry rat a very active hunting for the source of the sound. The method of procedure was as follows: One experimenter was placed behind a screen at the end of the box marked MN in figure I. A dish of sunflower seed was placed at the position of each of the sounders, S and S′. The other experimenter took the regular position in front of the box. When the animal was placed in the entrance alley (EA) the

experimenter behind the screen would rattle the seeds in the dish at the head of the open return alley. Punishment was given for wrong choice. Rat number 52 in group VII was given 280 trials under such conditions. The record by series runs: 60, 80, 75, 65, 50, 75, 70, 65, 55, 70, 75, 50, 75, 65. Since no signs of improvement were appearing the work was dropped.

Because of the above considerations the conviction was reached that the failure to learn the positive response to the sound stimulus was not due to the animals' being negative to the sounds presented.

The fourth possible explanation for the failure that suggested itself was that the rat could not localize the sounds well enough under the circumstances to enable it to guide its responses by them. This does not mean that the rat can not localize sounds, but that, if it can, the conditions under which the experiments were conducted were not suited to call localization into play. When the experiments began it was assumed that the rat could localize sufficiently well under the conditions presented to enable it to guide its response by the sound after a certain period of training.

The records for Groups VI and VII contain some significant things that require some comment and explanation. It will be recalled that pain for a wrong choice was given in these two groups. The records show that Numbers 42, 46, 47, 48, and 50 gave considerable evidence that they were actually learning the response. The fact is, Numbers 42, 47 and 50 actually met the standard required, that is, 95 correct responses out of 100 chances. Why was it that these records were not accepted as indicating that those animals had learned the sound? The fact was that their general behavior did not indicate definitely enough that they were actually responding to the sound stimuli when they were making enough correct responses to come close to meeting the standard required. The experimenter became convinced that some other factor was present in these cases as the determining factor. To make plain the basis for this conviction let us notice again the method of procedure. The keys which closed the circuit containing the induction coil and controlled the electric current used

for punishment were located just to the left of the keys (K and K′) used for working the sounders. The method of procedure had regularly been to use the left hand for working the 'sounder' keys and the right for opening and closing the doors of the box whenever necessary and for handling the animal. To have the left hand free to work the 'sounder' keys the right was also used to work the 'punishment' keys whenever necessary. The various movements made by the experimenter were usually as follows: The left hand remained resting at the 'sounding' keys while the right was used in adjusting the return doors (RD and R′D′ in figure I) and in putting the animal into the entrance alley (EA). Then the proper 'sounder' key was manipulated by the left hand and the sound stimulus given until a choice had been made, the right hand in the meanwhile resting upon the edge of the box. If a wrong choice had been made the sound was discontinued and the right hand was stretched across to the 'punishment' key and punishment given. In case of the animals mentioned above as showing evidence by the records of learning the required response the experimenter became convinced from observation of the general behavior that it was this very evident motion of the right hand or perhaps of his whole body that in some way served as a warning when about to enter the wrong alley. So a change was made in procedure. Instead of using the right hand for pressing the 'punishment' key, the right hand was allowed to remain lying on the edge of the box and the left was slipped as unobtrusively as possible from the position of the 'sounder' keys to that of the 'punishment' keys. A comparison of the records for five series before this change was made and for five series after the change was made will be surprising. Practically every animal which gave evidence that the response was being learned showed a considerable decrease in efficiency of response after this change was made. For the sake of comparison I have gathered them together in the following table:

	Before					After				
No. 39....	65	60	80	80	90	45	85	80	55	50
No. 40....	65	50	55	80	80	55	65	65	70	40
No. 41....	85	75	80	80	95	75	70	70	55	40
No. 42....	100	90	90	95	100	50	60	80	70	65
No. 43....	80	85	80	90	95	75	55	45	60	70
No. 45....	65	45	80	75	65	55	50	45	55	60
No. 46....	95	95	100	95	80	50	40	70	60	80
No. 47....	95	100	100	100	100	85	60	65	70	65
No. 48....	80	95	95	90	80	20	40	65	55	60
No. 49....	80	70	95	95	65	50	55	60	70	70
No. 50....	90	85	100	100	100	60	65	75	70	80
No. 51....	85	90	65	80	75	70	60	40	45	65
No. 52....	55	75	70	80	80	35	55	50	..	..

These records indicate that it is highly probable that the rats were depending in part at least upon certain movements made by the experimenter rather than upon the sound stimulus which was to serve as the guide in making the choice.

This complete failure to get any rats, either trained previously with the light or wholly untrained, either with punishment for wrong choice or without punishment, to learn the positive response to any sound stimulus presented was one of the most surprising results of the experiments. As suggested above the most plausible reason for this failure seems to be that the rats were unable to localize the sound sufficiently well under the conditions of the experiment to enable them to utilize the sound in learning the response required.

However, it would not be correct to say that these animals trained with the sound made no improvement at all. The fact is that all of them actually made improvement during the first 300 trials. To what was this improvement due? To answer that question we need first to know the amount of improvement made. We find that Group III in the first 100 trials made 49.8 per cent of correct responses, while in the fourth 100 trials the same group made 61 per cent of correct responses. Group IV in the first 100 trials made 51.2 per cent of correct responses, while in the fourth 100 trials the same group made 60 per cent of correct responses. Group V in the first 100 trials made 53.6 per cent of correct responses, while in the fourth 100 trials the same group made 65.8 per cent of correct responses. Thus roughly for the three groups the gain amounted to about 10 per cent.

We have already called attention to the fact, that with the series of choices required, chance would account for 50 per cent of correct responses and simple alternation between left and right would account for 70 per cent of correct responses. We have also called attention to the fact that the records show a tendency toward simple alternation in the case of the sound stimulus, but that there was no consistency at all in maintaining such an alternation. We are led to conclude, therefore, that *whatever gain was made by those animals trained with the sound stimulus was due to a partial perfecting of the simple alternation position habit.* In the case of those which learned the positive response to the light stimulus, since there is no direct evidence in the records of such a position habit having been acquired while learning the light, we would be led to believe that the light stimulus itself became the increasingly dominant factor right from the beginning of the learning process. However, when those same animals were transferred to sound, the records immediately show, as we have pointed out, that such a position habit had been partially formed. Thus the evidence seems conflicting. However, the conclusion seems warranted that chance and simple alternation, imperfectly carried out, will account for 60 per cent of correct responses when using such a series as was used in the experiments with positive response. Since such improvement is made in the first 300 trials any improvement beyond that amount, whether during the first 300 trials or later, must be accounted for in other ways. Thus Group I required only 120 trials with the light stimulus to surpass 60 per cent. Group II needed only 180 trials to surpass 60 per cent. Our conclusion must be that the light stimulus began to be effective in both cases not later than during the second 100 trials and reached its maximum influence at the end of 500 trials.

But we still have the question why it required those trained with the light only 120 and 180 trials to reach an efficiency of 60 per cent whereas it required those trained with the sound 300 trials to reach the same point. We have already found that the sound stimulus had no influence since it could not be localized. We have, therefore, to take account of the light only. In one case it was present

and in the other case it was absent. Therefore we must account for the rapidity with which the 60 per cent standard was reached in the first case as compared with the second by means of the effect of the light stimulus. Therefore we can conclude that the light stimulus was a factor practically from the beginning in learning the response, although upon the removal of the light the position habit, gained partly through the influence of the light and partly by mere repetition, still remained effective.

(3) Summary,—

(*a*) White Rats do not localize sounds sufficiently well to make use of them as a guide in learning under the conditions of these experiments.

(*b*) Movements of the experimenter can be utilized by white rats as cues which aid materially in the learning process.

(*c*) White rats will not learn and maintain consistently, under the conditions of these experiments, a simple alternation position habit even though given 1700 trials.

(*d*) In learning such a series as the one used in these experiments where a simple alternation position habit is of considerable value in getting the correct order of responses, such a position habit is not formed first independently of the light stimulus and then the learning process completed in terms of the light stimulus.

Rather there is evidence that the light stimulus is more or less effective in helping to establish whatever position habit enters into the order of responses and is wholly effective in carrying the learning process beyond the point where position habit alone could carry it.

(*e*) The learning process in this sort of problem is evidently very gradual, though somewhat irregular, having neither a rapid initial rise nor a long final perfecting of the response.

B. *Negative*

(1) Light,—Six groups of animals, VIII, IX, X, XI, XII, XIII, were taught the negative response to the light stimulus. The results have been summarized in the following tables:

GROUP VIII

Animal	Trials	Series
No. 53	255	17
No. 54	255	17
No. 55	240	16
No. 56	195	13
No. 57	255	17
No. 58	225	15
Average	237.5	15.8

GROUP IX

Animal	Trials	Series
No. 77	210	14
No. 78	255	17
No. 79	225	15
No. 80	285	19
Average	243.75	16.25

GROUP X

Animal	Trials	Series
No. 93	210	14
No. 94	195	13
No. 95	180	12
No. 102	210	14
No. 99	180	12
Average	195	13

GROUP XI

Animal	Trials	Series
No. 84	120	8
No. 85	165	11
No. 86	195	13
No. 91	150	10
No. 97	165	11
No. 101	120	8
Average	152.5	10.2

GROUP XII

Animal	Trials	Series
No. 81	225	15
No. 82	225	15
No. 89	225	15
No. 90	165	11
No. 98	135	9
Average	195	13

GROUP XIII

Animal	Trials	Series
No. 83	195	13
No. 87	195	13
No. 88	165	11
No. 92	210	14
No. 96	135	9
Average	180	12

Average for 31 animals, 198.87 trials, 13.26 series.

To understand these tables it is necessary to recall that with the negative response the stimulus was given in but 15 trials out of each series of 20 trials, the other five trials in each series being used for control tests as explained under method of procedure.

The important question here would be whether we can be sure that the responses were actually made to the light. As far as the writer could tell the other possible types of stimuli which might have been functioning were the sight of the experimenter's movements, the mechanical jarring of the apparatus produced by working the keys, and the kinaesthetic which would show itself in turning habits due to regularity of position and order of the required turning. As to the first mentioned, as much care was exercised as was possible to make such movements inconspicuous. The

keys were not in the range of the animal's vision and the finger movement or forearm movement necessary to work them was also below the line where vision might function. This result was secured mainly by having the alleys six inches deep, making it practically impossible for the animals to see any extraneous object or movement except where it appeared immediately over the alley. The rest of the experimenter's body was practically immobile during the time in which the reaction was to be made. As to the mechanical jarring of the apparatus, the extremely light touch necessary to work the keys would certainly render the jarring negligible. In the writer's opinion the most likely to manifest itself of the three possible types of things mentioned above is the third. When an animal is required to turn back fifteen times out of every twenty, it is extremely probable that it will acquire a habit of turning back, even when no stimulus has been given. As has been stated the series of trials used was particularly arranged to meet such a contingency. The possibility of "order in the series" functioning was eliminated by introducing irregularly the trials when the stimulus was omitted. The possibility of "position in the alley" functioning was eliminated by constantly varying the point at which the sound or light stimulus was given. Finally in cases where the animal did turn back and entered the other return alley when no stimulus was given by the experimenter or before such stimulus had been given, the stimulus was given in the other alley and the animal required to return to the alley first chosen to get back to the food box. Since such cases were confined practically to the work with the sound stimulus we shall omit the discussion of them here. These cases were so rare when using the light that they can well be neglected in considering the results.

The outstanding feature of the learning process here is the shape or form of the learning curve. To bring out the peculiar features more plainly, a number of curves are presented. These curves show the record not only for learning the light but also for the transfer to sound and pain. See Figures V to XIII inclusive.

It will be noticed that these curves show a period at first,

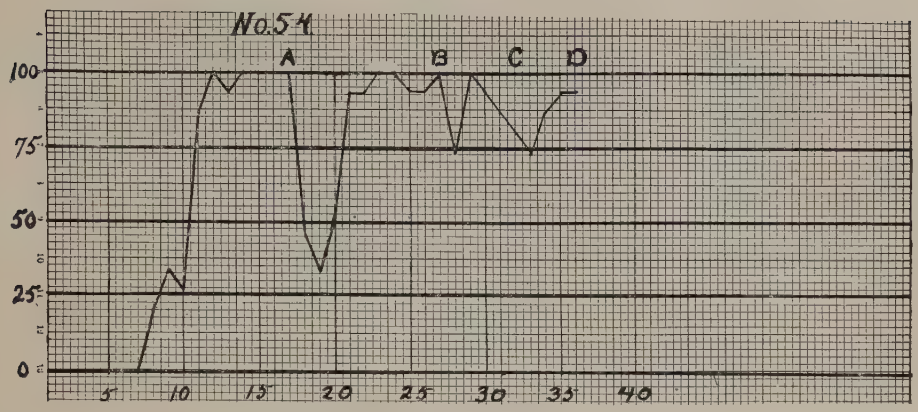

FIGURE V

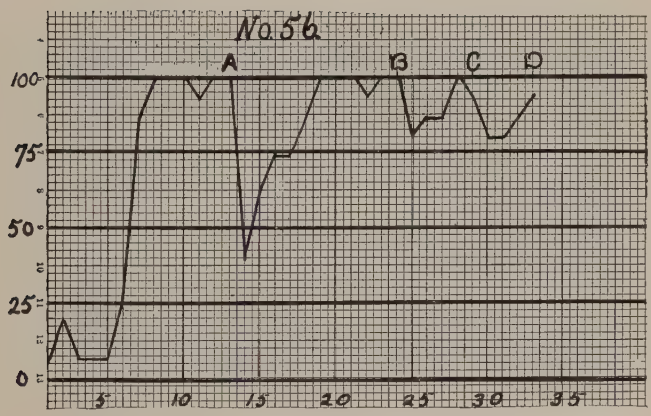

FIGURE VI

Curves 54 (Figure V) and 56 (Figure VI) are individual curves from Group Eight. The horizontal lines represent the percentage of correct responses. The vertical lines represent the number of series of 20 trials each. In lettering,—A is the end of the learning process with light, B is the end of the learning process with the regular sound stimulus, C is the end of the learning process with the bell, D is the end of the learning process with the pipes.

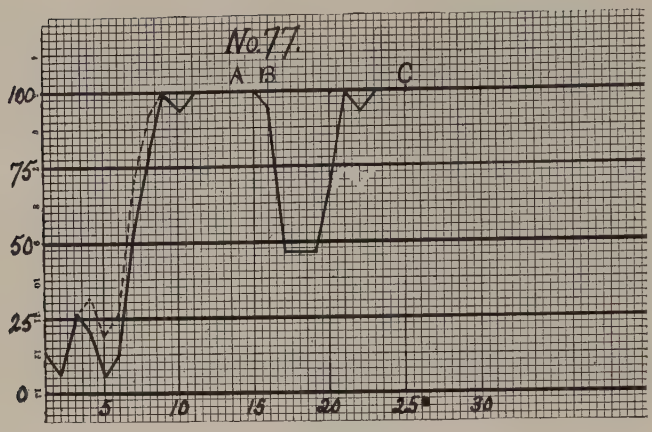

FIGURE VII

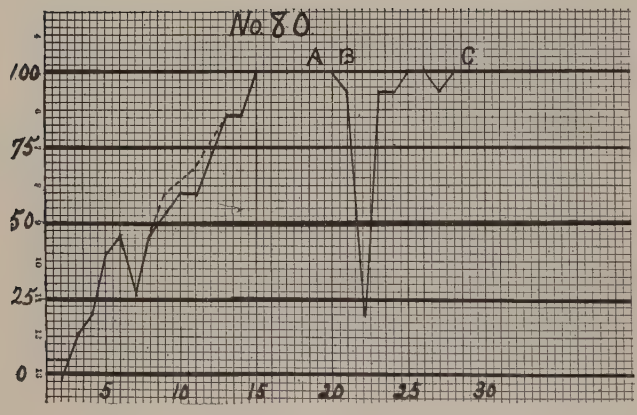

FIGURE VIII

Curves 77 (Figure VII) and 80 (Figure VIII) are individual curves from Group Nine. The horizontal lines represent the percentage of correct responses. The vertical lines represent the number of series of 20 trials each. The dotted lines represent the record for correct responses and for hesitations. In lettering,—A is the end of the learning process with the light, B is the end of the simultaneous series, C is the end of the learning process with the sound.

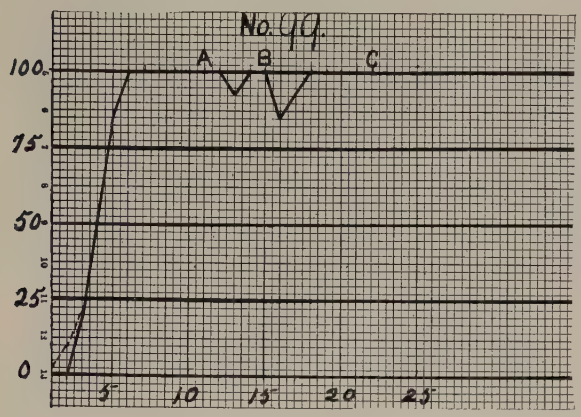

FIGURE IX

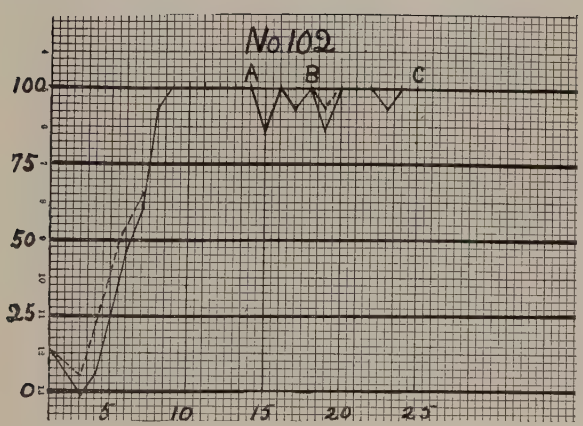

FIGURE X

Curves 99 (Figure IX) and 102 (Figure X) are individual curves from Group Ten. The horizontal lines represent the percentage of correct responses. The vertical lines represent the number of series of 20 trials each. The dotted lines represent the record for correct responses and for hesitations. In lettering,—A is the end of the learning process with the light, B is the end of the simultaneous series, C is the end of the learning process with the sound.

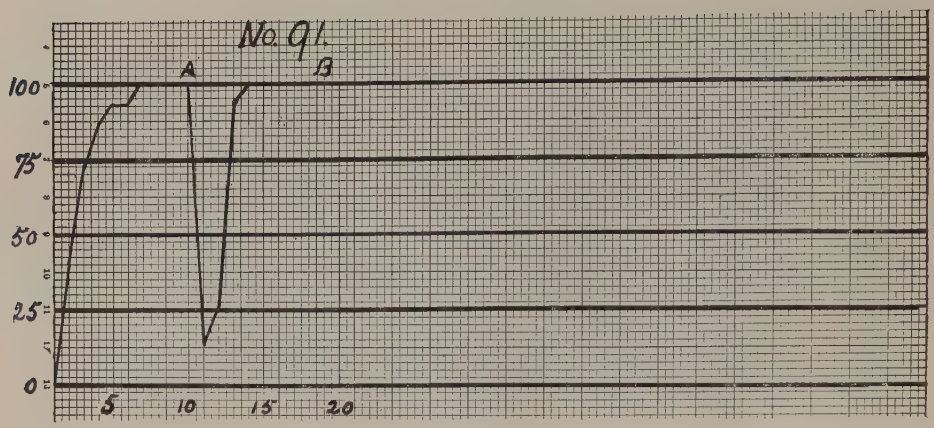

FIGURE XI

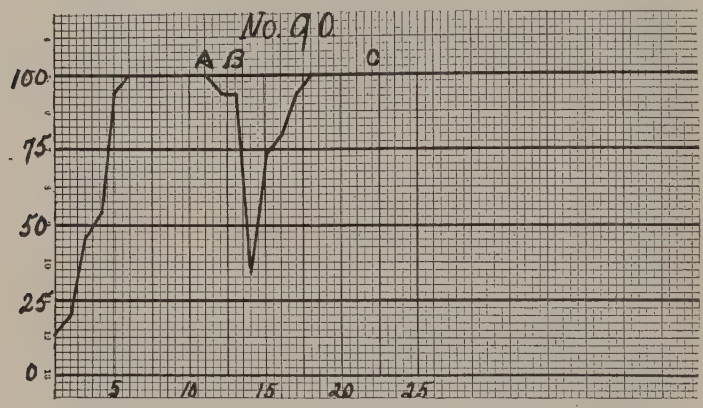

FIGURE XII

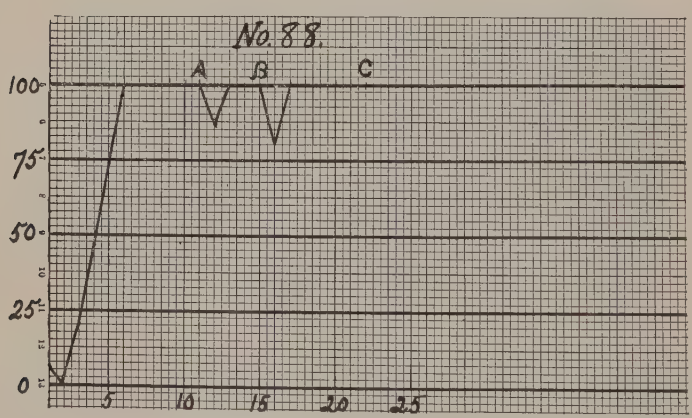

FIGURE XIII

Curve 91 (Figure XI) is an individual curve from Group Eleven. Curve 90 (Figure XII) is an individual curve from Group Twelve. Curve 88 (Figure XIII) is an individual curve from Group Thirteen. The horizontal lines represent the percentage of correct responses. The vertical lines represent the number of series of 20 trials each. In lettering,—A is the end of the learning of the light, B, in curve 91, is the end of the learning with the electric shock, and is the end of the simultaneous series in curves 90 and 88, C is the end of the learning process with the electric shock.

although short, of practically no learning, then a very sudden jump up to perfect response, rather than the sudden initial rise and the final long period of perfecting the process found in many learning curves. In the dotted curves it appears that the steepness of the ascent is modified a little in some cases. These take into account not only the correct responses but also the "hesitations" and the times of 'slowing up' due to the stimulus presented. But the light was learned so quickly that little difference is made by taking these additional evidences of learning into account. The few series necessary for learning the light also prevents the early period of non-learning from standing out clearly. One individual case in particular, number 84 in Group XI, illustrates the rapidity of learning very strikingly. The first series in this animal's record shows one correct response out of 15 chances, this one being the last of the fifteen. The next six series show a perfect record. This makes its record run as follows, counting in per cent of correct responses: first series, 6 2-3 per cent; second series, 100 per cent; third series, 100 per cent; fourth series, 100 per cent; fifth series, 100 per cent; sixth series, 100 per cent; seventh series, 100 per cent. One could scarcely find anywhere a record in animal learning that would equal it.

Since similar phenomena appear in learning the negative response to the other sorts of stimuli used, discussion will be reserved until those results have also been given.

(2) Sound,—Six groups of animals, XIV, XV, XVI, XVII, XVIII, XIX, were taught the negative response to the sound stimulus. The results have been summarized in the following tables:

Group XIV		
Animal	Trials	Series
No. 59	345	23
No. 61	465	31
No. 63	540	36
No. 64	435	29
No. 65	465	31
Average	450	30

Group XV		
Animal	Trials	Series
No. 60	450	30
No. 67	375	25
No. 68	345	23
No. 69	300	20
No. 70	345	23
No. 73	405	27
Average	370	24.66

GROUP XVI

Animal	Trials	Series
No. 62	540	36
No. 66	495	33
No. 72	285	19
No. 74	405	27
No. 75	450	30
No. 76	450	30
Average	437.5	29.16

GROUP XVIII

Animal	Trials	Series
No. 129	795	53
No. 130	765	51
No. 131	630	42
No. 132	795	53
No. 133	795	53
Average	756	50.4

GROUP XIX

Animal	Trials	Series
No. 152	705	47
No. 153	630	42
No. 154	645	43
No. 155	630	42
No. 156	705	47
Average	663	44.2

Average for 27 animals, 525.5 trials, 35.03 series.

The record for Group XVII is not included in the average with the remaining groups since we were compelled to make some changes in the method of procedure with that group. It was the first group to which we attempted to teach the negative response to sound and by means of it a final method was worked out. We gave the seven members of this group on the average fifty series of trials with the same sort of series as was used in the positive response previously reported and with the single sounder located in the food box and marked S in figure II. After the complete failure of all seven animals to show any evidences of learning in the fifty series of twenty trials each except such as could be ascribed to position habits, the three sounders along each side of the experiment box were introduced and the type of series adopted which was used in all the experiments with the negative response. After these changes were made the record for this group in learning the sound is practically the same as the normal record for sound secured later with the other groups reported.

To bring out the main features of the learning process when the sound was used, I have inserted a few typical curves. These curves show the same general features as those illustrating the learning with the light. In these curves, however, some of the distinctive features show up

much more plainly than in those for the light stimulus. These curves show the complete record for the animals, both while learning the sound and when transferred to the light and pain. Figures XIV to XVII.

The significant features of the learning process with the negative response to the sound stand out most clearly in the individual curves presented. These features have already been mentioned—the rather long period of no progress at first, the sudden and rapid perfecting of the response when once learning begins, and the few errors after once the response is learned. An apparent exception is the record of number 61 of group XIV. Here the early part of the record is very irregular until the eighteenth series, when it rises regularly and rapidly to perfection at the twenty-fifth series. In contrast with this record stands that of number 67 of Group XV. No sign of learning was shown there until the thirteenth series and learning was practically complete in the twenty-first series. Or still more striking is the contrast shown by the record for number 154 of Group XIX. While there is some slight evidence from "hesitations" that the sound stimulus was being noticed from the very first, not until the thirty-fifth series did good evidence of learning appear, and learning was practically complete by the thirty-eighth series. The record for number 129 of Group XVIII shows the most gradual rise of any, although for seventeen series, there is scarcely any sign of learning. For this rat it took thirty-one series to complete the learning after it began to exhibit progress whereas the usual number with the sound is much less, one even falling as low as four. It is the only case where the learning can be truly spoken of as a gradual process.

(3) Pain,—Seven groups of animals, XX-XXVI inclusive, were taught the negative response to pain. All of these represent normal records except Group XXII. Its record, therefore, has been omitted. This group was the first to be trained with the pain stimulus and served in part to work out the particular method for giving the pain stimulus. At first the stimulus was given at one point only as the animal came down the alley, the point being

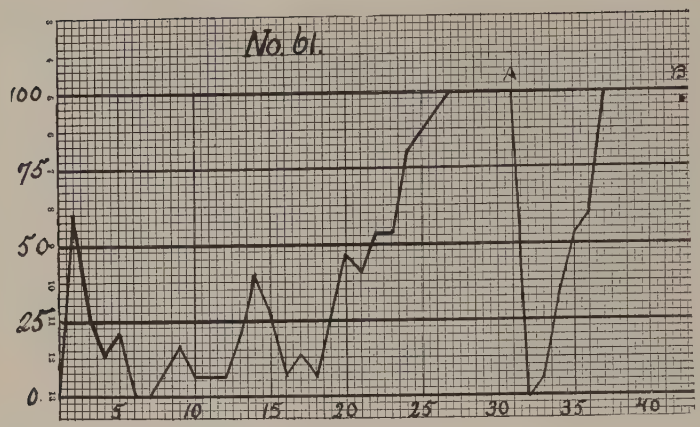

FIGURE XIV

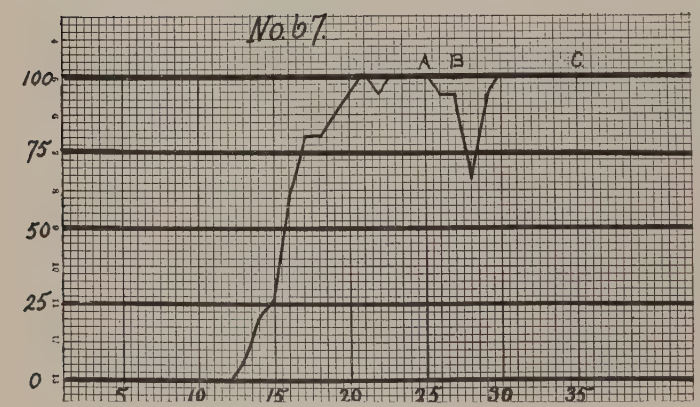

FIGURE XV

Curve 61 (Figure XIV) is an individual curve from Group Fourteen. Curve 67 (Figure XV) is an individual curve from Group Fifteen. Ho izontal lines represent percentage of correct responses. Vertical lines represent the number of series of twenty trials each. In lettering,—A is the end of the learning process with the sound, B (in curve 61) is the end of the learning process with the light, B (in curve 67) is the end of the simultaneous series, C (in curve 67) is the end of the learning process with the light.

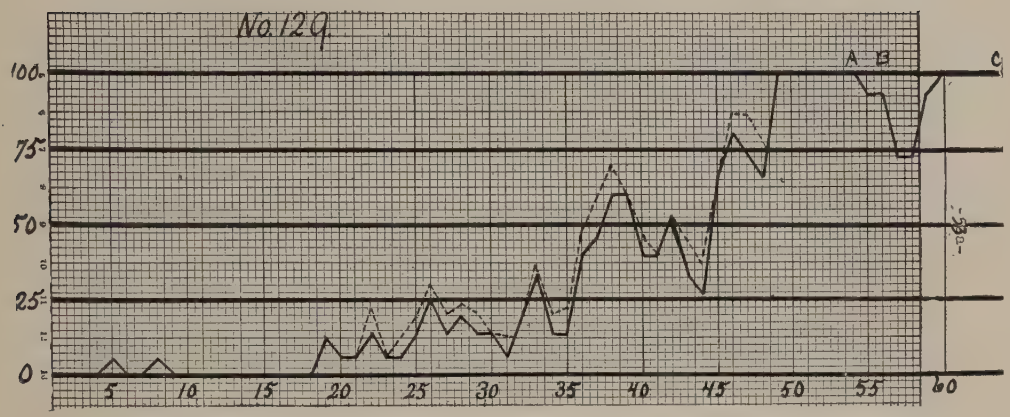

FIGURE XVI

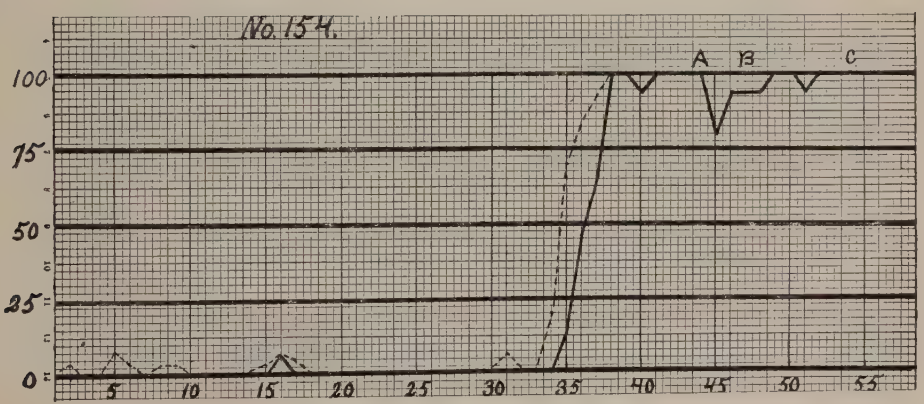

FIGURE XVII

Curve 129 (Figure XVI) is an individual curve from Group Eighteen. Curve 154 (Figure XVII) is an individual curve from Group Nineteen. Horizontal lines represent the percentage of correct responses. Vertical lines represent the number of series of twenty trials each. Dotted lines represent the record both for hesitations and for correct responses. In lettering,—A is the end of the learning process with the sound, B is the end of the simultaneous series, C is the end of the learning process with the pain.

varied from trial to trial. However, later to make the conditions more nearly uniform with the training given with other sorts of stimuli, the stimulus, when once given, was continued until the animal turned back. The following tables summarize the results:

GROUP XX

Animal	Trials	Series
No. 165	210	14
No. 166	210	14
No. 167	195	13
No. 170	150	10
Average	191.25	12.75

GROUP XXI

Animal	Trials	Series
No. 162	210	14
No. 163	240	16
No. 164	165	11
No. 168	165	11
No. 169	210	14
Average	198	13.2

GROUP XXIII

Animal	Trials	Series
No. 157	195	13
No. 158	180	12
No. 159	150	10
No. 160	210	14
No. 161	240	16
Average	195	13

GROUP XXIV

Animal	Trials	Series
No. 146	195	13
No. 147	150	10
No. 148	195	13
No. 149	225	15
No. 150	150	10
No. 151	180	12
Average	182.5	12.17

GROUP XXV

Animal	Trials	Series
No. 141	180	12
No. 142	165	11
No. 143	150	10
No. 144	135	9
No. 145	180	12
Average	162	10.8

GROUP XXVI

Animal	Trials	Series
No. 134	270	18
No. 135	255	17
No. 136	225	15
No. 137	195	13
No. 138	180	12
No. 139	165	11
Average	215	14.3

Average for 31 animals, 191.13 trials, 12.74 series.

A number of illustrative curves are given below. These curves show the record of these animals not only while learning the response to the pain stimulus, but also when transferred to the other sorts of stimuli. They will be referred to later also when discussing transfer from pain to light and sound. See Figures XVIII to XXI inclusive.

Here again practically all curves show a period of no progress at the beginning, then a rapid rise to perfection and no long process of perfecting.

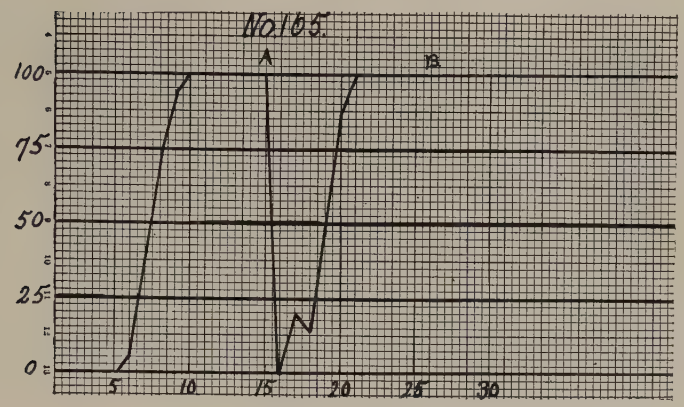

FIGURE XVIII

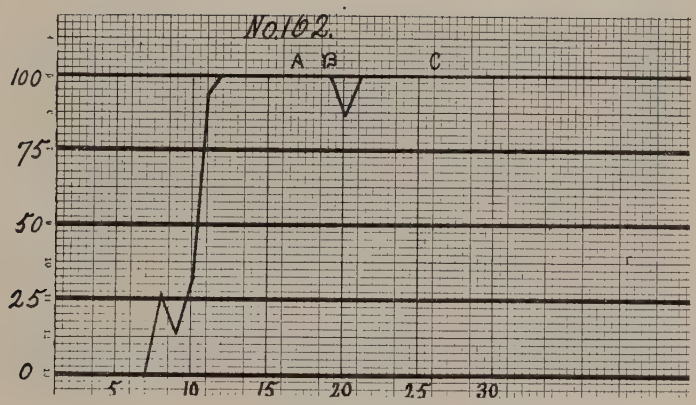

FIGURE XIX

Curve 165 (Figure XVIII) is an individual curve from Group Twenty. Curve 162 (Figure XIX) is an individual curve from Group Twenty-One. Horizontal lines represent the percentage of correct responses. Vertical lines represent the number of series of twenty trials each. In lettering,—A is the end of the learning process with the pain, B (in curve 165) is the end of the learning process with the light, B (in curve 162) is the end of the simultaneous series, C (in curve 162) is the end of the learning process with the light.

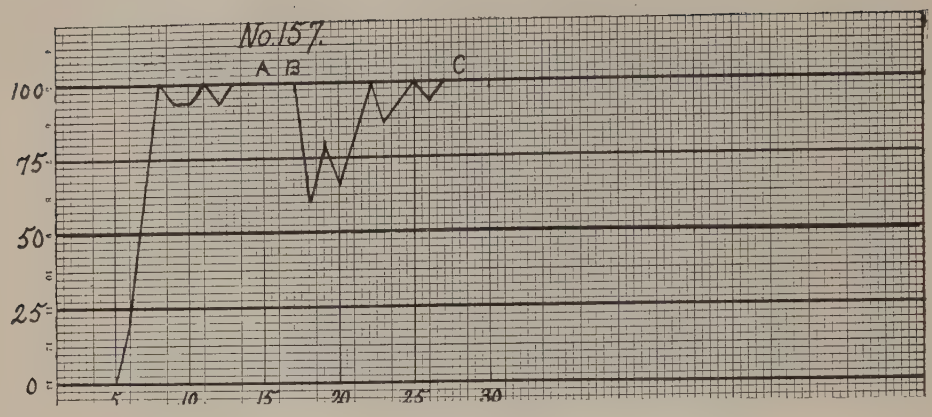

FIGURE XX

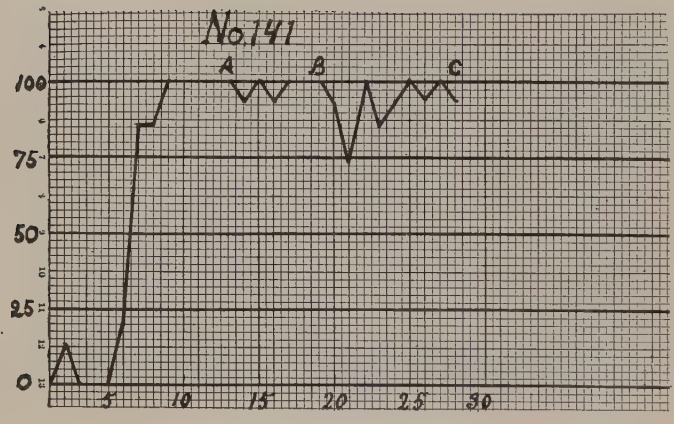

FIGURE XXI

Curve 157 (Figure XX) is an individual curve from Group Twenty-three Curve 141 (Figure XXI) is an individual curve from Group Twenty-five. Horizontal lines represent the percentage of correct responses. Vertical lines represent the number of series of twenty trials each. In lettering,—A is the end of the learning process with the pain, B is the end of the simultaneous series, C is the end of the learning process with the sound.

Another noticeable feature in these cases is the smoothness of the rising curve. It seems that when once the process is started there is practically no loss, but what is gained in one day's work is retained in the next in practically all cases. This last feature does not stand out so strikingly in the curves for learning the negative response to the light stimulus, and still less in the curves for learning the sound stimulus.

Another interesting feature closely related to the one just mentioned is the almost complete absence of marked plateaus. The curves for pain are the freest, those for light next, and those for sound least free.

This feature would indicate that for white rats working under the conditions of these experiments with negative response, the electric shock is the most uniformly effective stimulus of the three sorts of stimuli used. The light ranks second, and sound ranks third. We have every reason to believe from their general behavior in the presence of the electric shock that white rats are naturally negative to such a shock. We do not have definite proof that white rats are negative to the light and sound used. From general observation of their behavior in the presence of the light and sound stimuli used the writer is inclined to believe that they are more likely to prove to be negative to the sound than to the light. The electric shock uniformly produced the greatest emotional disturbance in the animals, calling for the greatest exercise of patience on the part of the experimenter. The electric shock most uniformly compelled the attention of the animal. The first few series of non-learning with the electric shock were not due to lack of attention to the stimulus as was quite evidently the case, in part at least, with the sound and light. Rather they were due to emotional disturbance produced by the strangeness of the stimulus. So these non-learning series might after all be counted as series indicating the acquirement of emotional adjustment to the stimulus rather than the specific response adjustment which the rise in the curve is supposed to indicate. Thus it might be claimed that, if an ideal learning process is one in which there is progress practically from the beginning and one which shows no

relapses nor plateaus, the process of learning the negative response to the electric shock in these experiments represents practically an ideal case.

There is no striking difference in the lengths of the non-learning periods for the pain and for the light. Neither is there any important difference in the number of series necessary to complete the learning process with the pain and with the light. The only really significant difference is in the smoothness of the rise of the curve in each case, yet this difference is not so great as to be very striking. It is likely due, as suggested above, to the greater power of compelling attention which the electric shock seems to possess. Its unlikeness, measured from the human standpoint, to anything else falling within the normal experience of the white rat might be the secret of its power.

But we still have the question of why the light was practically just as effective as the electric shock while the sound was decidedly less effective, having both a much longer non-learning period, a much greater irregularity of effectiveness, and a much longer learning period. Why this advantage of light over sound if the animals are really negative to neither? As suggested above, the animals seemed more inclined to be negative to the sound than to the light, if we are to judge from the general disturbance in their behavior produced by the two. If this were true, one would expect the response to the sound to be learned more quickly than to the light. Just the opposite was the case. Moreover, the animals were evidently negative to the electric shock but not to the light. Yet they learned the response to the light in practically the same way and practically as quickly as to the electric shock. But it might be that the greater emotional disturbance caused by the electric shock offset its greater effectiveness due to the animal's being negative to it. Perhaps the explanation of the comparative effectiveness of the light and sound can be found partly in the general conditions under which the experiments were conducted. It was much easier to control the light from external sources than the sound. So the light when presented represented a more uniform contrast with the general environment than the sound when it was

presented. This more uniform contrast might have increased the effectiveness. Then we still have the problem of the comparative intensities of stimuli from the different sense fields. For instance, how intense a sound shall be considered to be equal to a given intensity of light or of electric shock? We have no way of determining this independent of the reaction of the animals. All that can be said in the present case is that under the conditions of the experiments the electric shock was the most uniformly effective stimulus, the light next, and the sound least, in establishing the required negative response.

Another interesting thing not indicated in the curves and tables was the attempt on the part of some of the animals when learning the response to the pain to avoid the stimulus by jumping over the places where the shock had been previously received. A few typical cases are those of numbers 114, 115, 124, 128. The record of number 114 is as follows: in the fifth series of trials, it jumped twice; in the seventh series, five times; in the eighth, four times; in the ninth series, once; in the eleventh series, twice. The record for number 115 is as follows: in the fourth series, once; in the fifth series, three times; in the eleventh series, once. The record for 124 is as follows: in the twelfth series, five times; in the thirteenth series, once; in the sixteenth and seventeenth, once each. The record for 128 is: in the eighth series, eight; in the tenth series, twice. All of these "jumps" occurred before the change of procedure took place as mentioned in the description of this series of experiments. That is, they all occurred when the pain stimulus was given at but one place in the alley rather than all the way down as was the case in the method finally used. It is noteworthy, too, that these "jumps" occurred as a sort of preliminary method of responding to the pain stimulus, since after the animal had really begun to choose, or, in other words, to make the correct response no attempt at such avoidance occurred. Not all the animals in this group which learned the pain stimulus attempted to avoid it in this way. The four animals mentioned are the best examples in the records.

The fact of "jumping" indicates a more or less definite

sense of location, although there is no evidence that the "jump" was even generally made at the place where the last shock had been received. Most of them occurred at the first place in the alley where it was possible to receive the shock or at the last place. Some few occurred at every place in the alley, that is, when the animal started down the alley, it jumped at *every place* where a shock was likely to be received and so completely avoided the shock. One would be led to suspect by gross observation that vision was mainly instrumental in guiding the reaction in this jumping.

(4) Summary,—If we are to gather together the results for learning the negative response we find the following facts outstanding:

(a) The electric shock is the most effective stimulus, both from the point of view of rapidity of learning and from the point of view of smoothness of the learning curve, there being practically no lapses and no plateaus.

(b) The effectiveness of the electric shock is probably due to the fact that the animals were negative to the shock. The failure to show progress from the beginning was likely due to the emotional disturbance produced by the strangeness of the stimulus.

(c) The superior effectiveness of the light over the sound was probably due in part but not wholly to the better control of general environmental conditions in the case of the light.

(d) *The inferior effectiveness of the sound in comparison with the light and pain might indicate also that the visual and tactual stimuli play a more important part in the regular life of the white rat than do auditory stimuli. While the tactual has always been assigned a prominent place, there has been a tendency to belittle the importance of the visual. Another result pointing toward and emphasizing the visual has already been mentioned in discussing the results of the experiments where pain was given as punishment for wrong choice when learning the positive response to the sound stimulus. Also, if "jumping" just reported is guided by vision, it furnishes an added case in point.

* Bearing on this point, see, Pearce, *Jour. Animal Behav.*, Vol. 7, No. 3, p. 177.

(e) Attention has been called to the unusual form of the majority of the individual learning curves of animals learning the negative response. Contrary to the nature of the ordinary animal learning curve the greatest improvement does not take place in the earlier trials, but there is at first a period of little or no progress and later a period of rapid improvement with a quick perfecting of the response. In form these curves come more nearly into agreement with Swift's curves on Learning to Toss and Catch Balls. *As far as the writer is able to discover, the curves given in this paper are the first animal curves of this nature to be reported. Going on the assumption that perhaps the difference was due to the fact that all the evidences of learning were not being recorded, an attempt was made to correct this failure by taking note of " hesitations " and " retardations " in the animals' actions which could evidently be assigned to the stimulus as cause. But even this did not " correct " the form of the curves. As far as could be determined " errors " or " choices," with modifications of the latter in the form of " hesitations " and " retardations of movement," were the only criteria which could be made use of in measuring the progress of learning or the relative rate of learning. Unless we posit some change in the organism which is produced by the various trials but which does not manifest itself extrinsically in measurable behavior until a certain degree of strength has been reached, and then manifests itself by taking almost complete control of the animal's activity in that situation, we are at a loss to account for the difference in the rate of progress of learning. That would mean that in certain kinds of problems we might expect learning curves of this kind or, in other words, that the shape of the learning curve depends in part upon the nature or kind of problem.

In contrast with these curves for the learning of the

* NOTE: Professor Yerkes, of Harvard, reports in his monograph on the Mental Life of Monkeys and Apes (Behavior Monographs, Volume 3, Number 1, 1916, page 68) that one of his animals (Julius) showed the type of learning curve found in the work reported in this paper and claims that never before has a curve of learning like this been obtained from an infra-human animal. However, his work was done subsequent to the work reported in this paper. The work reported here was done during 1913 and 1914, but, owing to unavoidable delay has not been published until now.

negative response, the curves for the learning of the positive response show none of these peculiar features. In the positive curves there is evidence of learning from the very beginning, the process is quite gradual until completed, the process is quite irregular, showing both lapses and plateaus, and when learning is once completed, the standard is not so consistently maintained as in the negative. Since the general situations in the two problems were quite alike and the specific stimuli used (light and sound) were quite alike, the different character of the responses required must be largely the cause of the striking differences in the learning curves. It is to be remembered that the negative curves for sound do not stand out in as great contrast as the other negative curves.

SECTION FOUR

FEATURES BEARING ON TRANSFER

A. *Positive*

(1) Light to Sound,—Two groups were trained with the light stimulus and transferred to sound. Group I was transferred directly from the light to the sound when once the response to the light had been learned. With Group II each animal was given ten series or two hundred trials with the light and sound stimulus presented simultaneously, after the response to the light had been learned, and then transferred to the sound.

The curves given on page 20 show the general results. These curves show the learning of the response to the light stimulus, but they also show the record for the control series in each case, the record for any simultaneous light and sound stimuli, and the record for the sound stimulus alone which was substituted for the light stimulus.

The immediate result of the transfer was that the two groups dropped in efficiency 36 per cent and 26 per cent respectively, or down to that degree of efficiency which can be accounted for by chance or position habits. Three of Group I were given 25 series or 500 trials with the sound alone and at that time showed an average efficiency of 72 per cent whereas they started the sound with an average of 67 per cent. The other two of this group were given 11 series or 220 trials with the sound, and ended with an average of 70 per cent, whereas they started the sound with an average of 55 per cent. All six members of Group II were given 20 series or 400 trials with the sound alone after the series with sound and light simultaneously and ended the 20 series with an efficiency of 67 per cent whereas they began the sound alone with an average of 73 per cent. As stated above a study of the records shows that the animals all began to depend almost wholly upon alternation when the sound was substituted for the light, although

they do not maintain it with any high degree of regularity at all. Because no promise of further results was evident and because of the negative results in learning sound with groups already reported the work with these animals was discontinued.

(2) Sound to Light,—Since no animals learned the positive response to the sound we had none to transfer from sound to light. This part of our program had to be abandoned.

B. *Negative*

(1) Light to Sound,—Three groups of animals were first taught the negative response to the light and then were transferred to the sound. Group VIII was transferred directly from light to sound. Group IX was given two series of simultaneous light and sound stimuli after having learned the response to the light and then were transferred to the sound. Group X was given four series of simultaneous light and sound stimuli after having learned the light and then were transferred to the sound. The results are gathered together in the following tables. These tables indicate the number of series and trials necessary for learning the response to the sound after having learned the response to the light, and after having been trained with, the simultaneous light and sound wherever such training was given. Illustrative curves showing the complete records of certain individuals may be seen on pages 33-35.

To understand these tables one must keep in mind that only fifteen chances to respond to the stimulus were given in each series of twenty trials.

GROUP VIII

This group was transferred directly from light to sound

Animal	Trials	Series
No. 53	150	10
No. 54	150	10
No. 55	150	10
No. 56	165	11
No. 57	150	10
No. 58	150	10
Average	152.5	10.16

GROUP IX

This group was given two series of simultaneous light and sound

Animal	Trials	Series
No. 77	165	11
No. 78	150	10
No. 79	165	11
No. 80	120	8
Average	150	10

GROUP X

This group was given four simultaneous light and sound

Animal	Trials	Series
No. 93.....	105	7
No. 94.....	105	7
No. 95.....	105	7
No. 99.....	105	7
No. 102.....	105	7
Average.....	105	7

SUMMARY OF RESULTS

	Trials	Series
Average for learning sound (negative) shown in normal records..	525.5	35.03
Gained by direct transfer.....	373	24.87
Gained by 2 simultaneous light and sound.....	375.5	25.03
Gained by 4 simultaneous light and sound.....	420.5	28.03

The first thing to be noticed in the results is the fact that it is a decided advantage in learning the response to the sound to learn first the response to the light and then substitute the sound stimulus for the light stimulus either directly or with a few intervening series in which the sound and light are simultaneously given. Thus it took on the average 35.03 series for the animals to learn the response to the sound when no previous training had been received in making such a response. But by training first with the light stimulus and then substituting directly the sound stimulus only, 25.96 series were needed for learning the response to both the light and the sound and only 10.16 of these series were used in learning the response to the sound. That represents a saving of 24.87 series in learning the response to the sound by first learning the response to the light. By presenting the two stimuli simultaneously for a few series after the response to the light had been learned, a greater saving was effected. Thus with two simultaneous series a saving of 25.03 series was secured, while with four simultaneous a saving of 28.03 series was secured. This means that by training with the light until the response had been learned and by giving four series with light and sound simultaneously, the animals were trained to respond to the sound alone with a sufficient degree of accuracy to enable them to meet the standard during the next seven series, the shortest possible time in which they could meet the standard set. It also means that the quickest way for

the animals to learn the response to the sound is not to train them directly with the sound right from the first, but is to train them first with the light, then give a few simultaneous light and sound series, and then give the sound alone. The latter method required only 24 series altogether for the light, for the simultaneous light and sound, and for the sound, while the former method required 35.03 series all told for the sound only.

With Group VIII after learning the response to the light and the sound of the regular electric sounder, tests were also made with the sound produced by striking a three inch bell with a rubber hammer. This bell was held by the experimenter in front of the box and below the vision of the animal. After tests with the bell, tests were also made with wooden pipes of 2048, 1024, 512 and 256 vibrations. These pipes were sometimes blown by the experimenter who handled the animals during the experiments and sometimes by an assistant who stood just behind the regular experimenter. In sounding the bell or pipes no attempt was made to make a regular continuous sound. The only attempt was to keep the sound of moderate loudness whether given irregularly or continuously. After a few trials with these devices as sounders, it was the usual thing for the animal to turn back at the first sound of the bell or the first "toot" of the pipe, that is, the transfer was practically perfect.

It was in these trials with the sound after having learned the light, that there was some evidence of "position in the alley" functioning as a stimulus to cause the return of the animal, that is, the animal would turn back without any sound stimulus having been given. In cases where the animal did turn back, when no stimulus was given by the experimenter or before such stimulus had been given, and entered the other return alley the stimulus was given in the other alley and the animal required to return to the alley first chosen to get back to the food box. Such cases, however, were rare. A few typical records run as follows: Number 77 made one false return out of 540 trials; number 78 made four false returns out of 580 trials; number 79 made three false returns out of 560 trials; number 80 made three false returns out of 580 trials; number 102 made

three false returns out of 500 trials. The number of false returns recorded run from none to four per animal. Since they were so few no record was kept except for a part of the animals used. It must be noted, however, that practically all of the false returns were made after the animal had learned the response to one stimulus and had been transferred to the other. Practically all of them also are to be found in the records where sound was the stimulus being used. Some of the false returns can be accounted for by extraneous sounds from outside the laboratory. These false returns, to the writer's mind, indicate that the response had become considerable of a reflex and any sort of stimulus of a kind similar to the one which had become effective was sufficient to set it off rather than a matter of habitual turning at a particular place in the alley or at a particular position in the series of trials; in other words, *the response had become generalized for stimuli of that sort.*

Another thing which indicates that the response had become generalized for all stimuli of the sound type which could be " sensed " by the animal is the record of Group VIII with the bell and the pipes. As indicated by the record no great decrease in ability to respond was produced by substituting these two sorts of stimuli for the regular sound stimulus. The tests with the bell and the pipes were given as preliminary tests of the rat's ability to hear tones. Electrically driven tuning forks were also tried, but it was found to be impossible to control the sound of the tuning forks sufficiently well to suit the type of reaction required or already learned by the animal. After being trained on the light and the regular sound, the animal's reaction took place so rapidly that a mere click of the sounder was sufficient to stop the headlong course of the animal and cause it to turn back into the other alley. After placing the animal in the main alley, so quick was the choice that time was scarcely to be had to press the key and give the sound as a warning to turn back. In the case of the tuning forks the time required to get the fork vibrating with sufficient ntensity to make a plainly audible tone (for the human ear) was so long that the animal had made the complete run up the main alley and down one of the return alleys before the fork had begun to give out such a tone. So the

work was abandoned as far as making it any further test for sensitivity to tonal stimuli was concerned. Hunter's work on Tonal Sensitivity in White Rats, recently published, makes it reasonably clear that the rats, in cases where the bell and pipes were used, were really reacting to the noise element of the stimuli and not to the tonal element. So even if the tuning forks could have been properly controlled for such a response as was here required, it is extremely doubtful whether the animal's action would have been affected by it.

(2) Light to Electric Shock — Three groups of animals were first taught the negative response to the light and then were transferred to the pain. Group XI was transferred directly from light to electric shock, Group XII was given two series of simultaneous light and electric shock after having learned the response to the light and then were transferred to the electric shock, Group XIII was given four series of simultaneous light and electric shock after having learned the response to the light and then were transferred to the electric shock. The results are gathered together in the following tables. These tables indicate the number of series and trials necessary for learning the response to the electric shock after having learned the response to the light, and after having been trained with the simultaneous light and electric shock whenever such training was given. Illustrative curves showing the complete records of certain individuals may be seen on page 36.

To understand these tables one must keep in mind that only fifteen chances to respond to the stimulus were given in each series of twenty trials.

GROUP XI

Direct Transfer

Animal	Trials	Series
No. 84	165	11
No. 85	165	11
No. 86	165	11
No. 91	135	9
No. 97	135	9
No. 101	180	12
Average	157.5	10.5

GROUP XII

Transferred after two simultaneous series

Animal	Trials	Series
No. 81	150	10
No. 82	180	12
No. 89	150	10
No. 90	135	9
No. 98	165	11
Average	156	10.4

GROUP XIII

Transferred after four simultaneous series

Animal	Trials	Series
No. 83.....	105	7
No. 87.....	105	7
No. 88.....	105	7
No. 92.....	105	7
No. 96.....	105	7
Average.....	105	7

SUMMARY OF TABLES

	Trials	Series
Average for learning electric shock, Normal Record given.....	191.13	12.74
Gained by direct transfer.....	33.63	2.24
Gained by two simultaneous.....	35.13	2.34
Gained by four simultaneous.....	86.13	5.74

Again in this series of experiments we find decided evidence of transfer. The question here would be whether first learning the response to the light helped or hindered the learning of the same response to the electric shock. The results show that by first learning the response to the light a saving of 2.24 series was made in learning the response to the electric shock. Whereas by introducing two series of simultaneous light and pain after learning the light a saving of 2.34 series was made in learning the pain, and by introducing four simultaneous a saving of 5.74 series was made or, in other words, by first learning the light and by making use of four series of simultaneous light and pain, the animals were able to meet the required standard for the pain in the next seven series, the smallest number possible.

One might wonder why only 2.34 series were gained by two simultaneous when 2.24 were gained by direct transfer and 5.74 series were gained by four simultaneous. The explanation may be found in the following fact. The stimulus was always more or less disturbing whenever an animal was introduced to it for the first time. This was particularly true whenever the electric stimulus was given alone. Considerable care and patience had to be exercised with the animals until they got over the emotional disturbance. This usually required about four series. The two or four simultaneous series, while not showing this disturbance in a uniformly low percentage of correct re-

sponses, yet served mainly, in the experimenter's opinion, to overcome the emotional disturbance produced by such a strange stimulus. It is very possible that if the electric stimulus had had as little disturbing effect emotionally as the light apparently had, the transfer effect would have been more in proportion to the number of simultaneous series given, and so more gradual in its increase. Practically the same type of result was found in the case of transfer from light to sound, where two simultaneous series showed very little advantage over direct transfer, while four simultaneous series produced considerable advantageous effect.

(3) Sound to Light — Three groups of animals were first taught the negative response to the sound and then were transferred to the light. Group XIV was transferred directly from sound to light. Group XV was given two simultaneous series of sound and light before being transferred to light. Group XVI was given four series of simultaneous sound and light before being transferred to light. The results are gathered together in the following tables. Illustrative curves are given on pages 40-41.

GROUP XIV

Transferred directly from Sound to Light. Summary of record for Light

Animal	Trials	Series
No. 59	165	11
No. 61	165	11
No. 63	150	10
No. 64	120	8
No. 65	150	10
Average	150	10

GROUP XV

Transferred with two simultaneous series of Sound and Light. Summary of Record for Light.

Animal	Trials	Series
No. 60	135	9
No. 67	120	8
No. 68	120	8
No. 69	120	8
No. 70	120	8
No. 73	105	7
Average	120	8

GROUP XVI

Transferred with four simultaneous series of Sound and Light
Summary of Record for Light

Animal	Trials	Series
No. 62	105	7
No. 66	105	7
No. 72	105	7
No. 74	105	7
No. 75	105	7
No. 76	105	7
Average	105	7

SUMMARY SHOWING EFFECT OF TRANSFER

	Trials	Series
Average for learning Light, Normal Record found	198.87	13.26
Gained by direct transfer from Sound	48.87	3.26
Gained by transfer with two simultaneous series	78.87	5.26
Gained by transfer with four simultaneous series	93.87	6.26

Little need be said here except to call attention to the fact that even in learning the response to the light which proved to be very easy for the animals, there was an advantage in first learning the same response to some other sort of stimulus. As in the series previously reported a few series with the two stimuli simultaneously given overcame almost entirely any loss there happened to be by passing directly from learning the one to learning the other.

(4) Sound to Pain — Three groups of animals were trained with the sound and transferred to the pain. Group XVII was transferred directly from sound to pain. Group XVIII was given two series of simultaneous sound and pain after learning the response to the sound and then were transferred to the pain. Group XIX was given four series of simultaneous sound and pain after learning the response to the sound and then were transferred to the pain. The results are gathered together in the tables given below. Illustrative curves are to be found on page 41.

GROUP XVII

Transferred directly from sound to pain

Animal	Trials	Series
No. 104	105	7
No. 105	120	8
No. 108	135	9
No. 109	120	8
No. 110	135	9
No. 111	135	9
No. 113	120	8
Average	124.3	8.3

GROUP XVIII

Transferred with two simultaneous series of sound and pain

Animal	Trials	Series
No. 129	120	8
No. 130	180	12
No. 131	120	8
No. 132	135	9
No. 133	150	10
Average	141	9.4

GROUP XIX

Transferred with four simultaneous series of sound and pain

Animal	Trials	Series
No. 152	105	7
No. 153	105	7
No. 154	105	7
No. 155	105	7
No. 156	105	7
Average	105	7

SUMMARY

	Trials	Series
Normal Record for learning pain found	191.13	12.74
Gained by direct transfer	66.83	4.44
Gained by two simultaneous	50.13	3.34
Gained by four simultaneous	86.13	5.74

Little comment is necessary here except to call attention to the fact that the direct transfer brought a greater saving in learning the pain series than the transfer with two simultaneous sound and pain series. Notice was called in the series of experiments where the animals were transferred from light to sound to a somewhat similar case where two simultaneous series produced little advantageous effect over direct transfer. In the present case the two stimuli, when simultaneously given for two series, actually proved a hindrance to transfer when compared with the direct transfer effects with the same two stimuli. *This is the only instance in all the experiments performed where simultaneous series proved less advantageous than direct transfer.*

(5) Pain to Light — Two groups of animals were transferred from pain to light. Group XX was transferred directly. Group XXI was given two series of simultaneous pain and light, after having learned the response to the pain, and then were transferred to the light. The results are given in the tables below. Illustrative curves are to be found on page 43.

GROUP XX

Transferred directly from pain to light

Animal	Trials	Series
No. 165	165	11
No. 166	165	11
No. 167	135	9
No. 170	120	8
Average	146.25	9.75

GROUP XXI

Transferred with two simultaneous series

Animal	Trials	Series
No. 162	105	7
No. 163	105	7
No. 164	105	7
No. 168	105	7
No. 169	105	7
Average	105	7

SUMMARY

	Trials	Series
Average for learning light, Normal Record found	198.87	13.26
Gained by direct transfer	52.62	3.51
Gained by two simultaneous	93.87	6.26

One interesting feature of the results is that even in the case of learning the response to the light, which was very easily acquired on the average, it turned out to be advantageous to learn first the response to the pain stimulus.

While two simultaneous pain and light series were given the second group and that number proved sufficient to perfect the transfer effect, yet it is the conviction of the writer from observation of the general behavior of the animals while the simultaneous series were being given that one series of simultaneous stimuli would have been sufficient. Since this series of experiments was the last to be performed, time prevented the testing out of that conviction.

Another interesting feature not shown in the regular tables and curves was the attempt to discover how many times an animal would turn back when the stimulus was presented, without being allowed to return to the food box after a correct response had been given. If the animal chose the right alley it was confronted with the stimulus. Then when it returned and entered the left alley it was again met by the stimulus. Then upon returning to the right alley, the stimulus was again given. This was continued until the animal disregarded the stimulus or until it refused to work longer. Number 168 turned back three times before disregarding the stimulus. Number 169 turned back seventeen times and then refused to work any longer. Number 162 turned back nine times before disregarding the stimulus; number 163 five times; number 164 eight times, and number 166 thirteen times. These figures indicate that the response had become reflex and also that it was not merely a habit of entering one alley and turning back and returning to the food box through the other. These tests were conducted with both doors to the food box open and some of the returns to the other alley were made when the animal was within sight of the open door to the food box. This test was tried only with the light stimulus and only with those animals which had been transferred from the pain to the light.

(6) Pain to Sound — Five groups were trained with the pain and transferred to the sound. Group XXII was transferred directly from pain to sound. Group XXIII was given two series of simultaneous pain and sound. Group XXIV was given four series of simultaneous pain and sound. Group XXV was given six series of simultaneous pain and sound. Group XXVI was given eight

series of simultaneous pain and sound. The following tables gather the results together. Illustrative curves will be found on page 44.

GROUP XXII

Transferred directly from pain to sound

Animal	Trials	Series
No. 114	420	28
No. 115	525	35
No. 116	150	10
No. 171	165	11
No. 117	150	10
No. 118	495	33
No. 123	450	30
No. 124	240	16
No. 125	495	33
No. 126	210	14
No. 127	285	19
No. 128	165	11
Average	312.5	20.83

GROUP XXIII

Transferred with two simultaneous series

Animal	Trials	Series
No. 157	165	11
No. 158	255	17
No. 159	135	9
No. 160	225	15
No. 161	120	8
Average	180	12

GROUP XXIV

Transferred with four simultaneous series

Animal	Trials	Series
No. 146	225	15
No. 147	210	14
No. 148	285	19
No. 149	180	12
No. 150	150	10
No. 151	210	14
Average	210	14

GROUP XXV

Transferred with six simultaneous series

Animal	Trials	Series
No. 141	135	9
No. 142	120	8
No. 143	105	7
No. 144	135	9
No. 145	105	7
Average	120	8

GROUP XXVI

Transferred with eight simultaneous series

Animal	Trials	Series
No. 134	105	7
No. 135	105	7
No. 136	105	7
No. 137	105	7
No. 138	105	7
No. 139	105	7
Average	105	7

SUMMARY

	Trials	Series
Average for learning sound, Normal Record found	525.5	35.03
Gained by direct transfer	213.	15.2
Gained by two simultaneous	345.5	23.03
Gained by four simultaneous	315.5	21.03
Gained by six simultaneous	405.5	27.03
Gained by eight simultaneous	420.5	28.03

It again stands out clearly that it is an advantage in learning one sort of stimuli to have first learned the same response to another sort of stimuli, and that a few simultaneous series will render the transfer effect sufficiently perfect for the animal to meet at once the standard of learning set up at the beginning. A glance at the tables will show, however, that a gradually increasing number of simultaneous series does not bring a gradually increasing advantage. Attention to this fact has been called in previous series of experiments. In the present case two simultaneous series proved more advantageous than four simultaneous series. Whether a larger number of animals would give an average which would eliminate this discrepancy and the ones previously reported is yet to be tested. Theoretically, one might expect them to be eliminated.

In order to get before us all the tabular results bearing on the problem of transfer, we have gathered them together and expressed the results, not only in the number of trials gained, but also in the percentage of gain. This will enable the reader to get at the amount and the conditions of transfer most quickly.

Light to Sound

	Trials	
Normal sound record...	525.5	
Gained by direct.....	373	88.7%
Gained by two simul....	375	89.1%
Gained by four simul...	420.5	100%

Light to Pain

	Trials	
Normal pain record.....	191.13	
Gained by direct.....	33.63	39 %
Gained by two simul....	35.13	40.7%
Gained by four simul...	86.13	100%

Sound to Light

	Trials	
Normal light record.....	198.87	
Gained by direct.....	48.87	52%
Gained by two simul....	78.87	84%
Gained by four simul...	93.87	100%

Sound to Pain

	Trials	
Normal pain record.....	191.13	
Gained by direct.....	66.83	77.5%
Gained by two simul....	50.13	58.2%
Gained by four simul...	86.13	100%

Pain to Light

	Trials	
Normal light record.....	198.87	
Gained by direct.....	52.62	56%
Gained by two simul....	93.87	100%

Pain to Sound

	Trials	
Normal sound record...	525.5	
Gained by direct.....	213	50.6%
Gained by two simul....	345.5	82.1%
Gained by four simul...	315.5	75 %
Gained by six simul.....	405.5	96.4%
Gained by eight simul..	420.5	100%

C. *Summary of Conclusions*—The results of the experiments reported in this paper go to support the general contention that " the fact of transfer can not be doubted," that is, of positive or advantageous transfer. It has been found that in every case learning a response to one situation, having a given element or stimulus as the dominant or controlling factor, is a help in learning the same response to the same situation but having a different element or stimulus, not present before, as the dominant or controlling factor; that even in some situations the learning process for one sort of dominant stimulus is actually reduced in length so much by first introducing another dominant stimulus, that the time and effort for both is less than for the one alone. Such was actually the case in learning the negative response to the sound.

Looking at the results from the point of view of " generalized response " or " generalized habit " we can say that responses are not always *particular*, but may become truly *general*; that is, the same response may serve for situations whose dominant stimuli are as different as can be found, provided the other features of the situation are the same and remain constant. This is really the reverse of the cases usually spoken of under the term " generalized habit." In such cases the dominant features are supposed to remain the same while the minor features vary from one case to another. So " generalized habit " can not always be said to depend upon similarity of dominant features in the situations responded to, or upon lack of discrimination of such dominant features. We can secure " generalized responses " where the dominant features of the situation are actually different for the organisms making the responses, provided we can take difference of *sense channel* as the basis for discrimination of stimuli. In such cases there would be difference of neural pathways, at least in the sensory portion of such pathways. The " identical elements " in such pathways would be at least partly in the association and motor portions. Complete identity can not be said to be present.

According to the results given, one, and the only one, of the conditions of the degree of advantageous or positive transfer clearly shown is the simultaneous presentation

of the two controlling or dominant stimuli after the response to one has been learned. While in practically every case considerable disturbance was produced at the introduction of the new stimulus along with the old, yet the presence of the old helped in every case in learning the new. In no case did it require more than eight series with the old and new together to perfect the response to the new. In one case, pain to light, it required only two series.

Would it be too much of a hazard to hypothesize thus.—Variations in stimuli allow of positive or advantageous transfer effects, while variations in response, an aspect of the problem which has not been tested in these experiments, produce negative effects?* Of course in any case where training of any sort has gone on in any general situation, the general familiarity with the situation will soon give a freedom from emotional disturbance and a general food seeking reaction. Both of these will tend to be carried over to later responses to the same general situation. These may offset any negative effects produced by a *simple* change in the response, unless, as was done with the experiments reported in this paper, the animals were first made perfectly familiar with the apparatus and with the ways back to the food box before any experimenting proper began, so that these factors were made as nearly equal in influence as possible.

These experiments are not to be regarded, nor are they regarded by the writer, as offering a final or complete solution of the problem of transfer. They are to be taken as offered—a very simple and humble beginning of the solution of that very complex problem. Our results have made clear that advantageous or positive transfer can and does take place in situations the most simple and have shown some of the conditions favoring such transfer. As the situations studied grow more complex it must be remembered that the conditions at work in these simpler situations *may* still account for many of the results obtained. On the other hand, however, with the introduction of many varying factors, both subjective and objective, the results for the simpler conditions may not hold at all.

* NOTE: Bearing on this suggestion, see
Hunter, *Jour. Animal Behav.*, Vol. 7, No. 1, pp. 49-65,
Pearce, *Jour. Animal Behav.*, Vol. 7, No. 3, pp. 169-177.

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